Module 1 Understanding human movement analysis
(Formerly what is 'normal movement')

THIS HANDOUT CONTAINS DESCRIPTIONS OF COMPONENTS OF MOVEMENT ANALYSIS THAT HAVE BEEN APPROVED AND/OR COMPILED BY THE BRITISH BOBATH TUTORS ASSOCIATION (BBTA).

This module will explore human movement analysis and the integration of postural control, sensory information and selective movement for function. It is applicable to therapists working in any setting, but the clinical focus will be on neurological rehabilitation.

The aims of the module are:

1. To discuss how movement analysis is used within the Bobath Concept
2. To explore and enhance skills of observation, analysis and handling
3. To link theory and practice
4. To promote clinical effectiveness, i.e. the extent to which specific clinical interventions do what they intend to do based on sound clinical reasoning'

The Bobath Concept is a problem-solving approach to the assessment and treatment of individuals with disturbances of function, movement and postural control due to a lesion of the nervous system (IBITA 2008). Treatment is an interaction between therapist and patient where facilitation leads to improved function (Raine 2007). Current Bobath practice is concerned with the relearning of more efficient functional movement through manipulation of a variety of afferent inputs. The contemporary Bobath Concept is based on a systems model of motor control, the concept of neuromuscular plasticity, principles of motor learning and an understanding and application of functional human movement. These are the foundations of the current Bobath concept and are reflected in the assumptions underlying clinical practice.

Motor control is the ability to regulate or direct mechanisms essential to posture and movement. It includes how the nervous system organises movements and how sensory information from the environment and the body contribute to this. *A systems model of motor control* is flexible and interactive and incorporates motor learning. It considers the integration of many systems and subsystems producing the required output to achieve a task (Shumway-Cook and Woollacott 2011). Key players include ascending pathways, thalamus, sensory and motor cortices, basal ganglia, cerebellum, brainstem nuclei, descending pathways and spinal cord circuitry including central pattern generators. Knowledge of how different parts of the nervous system connect to each other is helpful in understanding control of movement.

Motor learning is defined as a set of processes associated with practice or experience leading to relatively permanent changes in the capability for producing skilled action; has been distinguished from performance defined as temporary change in motor behaviour seen during therapy (Shumway-Cook and Woollacott 2011). Principles include *active participation*,

British Bobath Tutors Association
10 Main Street, Crawcrook, Gateshead, Tyne & Wear, NE40 4ND
E: enquiries@bbta.org.uk
T: 0191 580 0567
T: @BBTATutors
W: www.bbta.org.uk

meaningful goals and *opportunities for practice*. Conditions of practice incorporate component versus whole task; mass versus distributed; blocked versus random; constant versus variable practice.
Movement emerges from an interaction of the *individual,* the *task* and the *environment* (*Shumway-Cook and Woollacott 2011*). Movement is both task specific and constrained by the environment. The individual generates movement to meet the demands of the task being performed within a specific environment. The individual's ability to meet interacting task and environmental demands determines that person's functional capability. It is evident that movement patterns are flexible and variable in intact subjects.

Within the *individual* movement develops from the interaction of *perceptual* [integration of sensory information, for example body schema], *action* [motor output to muscles], and *cognitive systems* [including attention, motivation and emotional aspects of motor control], with cognition affecting both perception and action systems at many different levels. A *task* may involve aspects of *stability* [sit / stand); *mobility* [walk / run] and / or *manipulation* [simple / complex]. *Regulatory features* specify aspects of the *environment* that shape the movement itself, for example the shape/weight of a cup to be picked up. *Non-regulatory* features may affect performance but do not necessarily change the movement itself, for example background noise and distractions (*Shumway-Cook and Woollacott 2011*).

Normal movement or activity may be considered to be a skill acquired through learning for the purpose of achieving the most efficient and economical movement or performance of a given task and is specific to the individual (*Edwards 2002*). A nervous system lesion may affect performance of voluntary movement and lead to abnormal or disordered movement. The literature describes disordered movement as being suboptimal / non selective / atypical. Movement patterns in the normal population represent a spectrum from clumsy / impaired movement at one end to perfection / uniquely specified movement at the other, that is the athlete (*Latash and Anson 1996)*. During movement analysis areas of inefficiency may be seen in an individual. The terms *inefficient / efficient* may therefore be more useful movement descriptors than normal / abnormal.

Qualities associated with high levels of *efficient* movement performance include*:*

- Goal achievement
- Minimum energy expenditure
- Minimum movement time (*Schmidt and Wrisberg 2000*)

Postural control mechanisms enhance movement efficiency and involve controlling the body's position in space for the dual purpose of orientation and stability. Postural orientation infers the active alignment of the trunk and head, through sensory afferent integration, and postural stability the co-ordination of movement strategies to stabilise the centre of mass (COM) during self initiated or external disturbances to balance (Horak 2006). In stance the COM must be maintained within the base of support. Limits of stability (the area over which an individual can move their COM and maintain stability without changing the body's orientation to the base of support) are shaped like a cone and are based on an internal representation or body schema. Stability limits are not fixed boundaries but change according to the task / individual / environment. In the person with neurological dysfunction altered body schema will impact on the recovery of postural control i.e. postural orientation and stability. Body schema provides an internal representation of the body geometry, body dynamics and body orientation with respect to verticality and is dependent upon multisensory inputs, visual,

British Bobath Tutors Association
10 Main Street, Crawcrook, Gateshead, Tyne & Wear, NE40 4ND
E: enquiries@bbta.org.uk
T: 0191 580 0567
T: @BBTATutors
W: www.bbta.org.uk

vestibular and somatosensory *(Massion 1994).* Postural reactions, anticipatory (preparatory and accompanying) during voluntary movement as well as flexible strategies for balance recovery after disturbance, are organised on the basis of this internal representation. Postural reactions occur in response to balance disturbances and include an ankle, hip and stepping strategy or grasp with the hand. Anticipatory postural adjustments, produced by voluntary movement, precede balance disturbance onset therefore minimising the effects of the forthcoming disturbance in a feed forward manner.

Two parallel supraspinal descending systems project to the spinal cord, the ventromedial brainstem pathways, which include the interstitiospinal and tectospinal tracts arising from the midbrain, the lateral and medial vestibulospinal tracts and the reticulospinal and bulbospinal projections arising from pontomedullary reticular formation and the dorsolateral descending pathways, which include the rubrospinal tract from the magnocellular red nucleus in brainstem and the corticospinal tract whose axons originate in the cortex (Lemon 2008). Descending systems are referred to as the 'motor system'. Other pathways that influence motor and other functions at spinal level include a medial component that comprises the raphespinal and coerulospinal pathways. These fibres terminate widely at all spinal levels in the dorsal horn and among autonomic and somatic motoneuronal cell groups. Neurotransmitters and neuromodulators in these pathways include serotonin and noradrenalin.

Each descending pathway has specific characteristics that determine its neuronal targets within the spinal cord and therefore its functional role. The lateral and medial descending systems are not completely separated, they inter-communicate at supraspinal levels and they also share common targets within the spinal cord. Each descending pathway may carry out a number of functional roles, these are linked together by the need for a coordinated set of operations underpinning performance of basic functions such as balance, posture, locomotion, and reaching. Distal movements require proximal postural activity, which itself is dependent upon distal orientation *(Canedo 1997, Felten et al 2003)*

Selective lesion effects on posture and movement have been studied in monkeys. Medial pathways are concerned with the maintenance of upright posture, integrated movement of the trunk and limbs and directing the course of progression. Monkeys with a medial lesion could not right themselves for 40 days. When they could finally walk they were unsteady with a narrow base of support and abducted limbs. They had difficulty staying on course and avoiding obstacles however distal extremity movements were relatively unaffected. Lateral pathways superimpose upon medial pathway control the capacity for independent use of the extremities, particularly the hand. A lateral lesion results in impaired ability to flex a limb and impaired individual digit movement. Monkeys could still sit unsupported, stand, walk, run and climb.

Goal directed functional behaviour can be analysed at the: a<u>ction level</u> (get in / out of bed); m<u>ovement level</u> (patterns and components); n<u>euromotor processes level</u> (strength / co-ordination). The study of movement provides a baseline for determining differences (that might arise due to pathology) based on observation of the interrelationship between key points' in relation to the base of support in a given postural set. Normal subjects demonstrate variable characteristics.

Key points of control are body segments, regions or areas that have inherently have their own selective control but they interact with the rest of the body. The key areas are **central** [the

British Bobath Tutors Association
10 Main Street, Crawcrook, Gateshead, Tyne & Wear, NE40 4ND
E: enquiries@bbta.org.uk
T: 0191 580 0567
T: @BBTATutors
W: www.bbta.org.uk

thorax-maximum rotation occurs at middle thoracic segments T6-T11], **proximal** [shoulder girdles and pelvis] and **distal** [hands and feet]. Key points develop an independent bias to certain systems on a form function basis. It is the assessment of the relationship of key points to each other and in relation to the environment that enables us to analyse movement more clearly. *Prime movers* (elbows and knees) are the main initiators for changing the patterns produced through key point control. They change the pattern within a limb through rotation and are vital for affecting the delivery of key point control. The key points are individual; interactive; interdependent; they can influence / interfere with movement patterns.

The *base of support* refers to the supporting surface the body part is in contact with and the relationship between whole body and supporting surface. It is not purely a mechanical relationship but a proprioceptive interaction between the body and the environment. The base of support acts as a reference point for movement within a posture and for movement from one position to another. The ability to accept / interact with the base of support includes the ability to eccentrically lengthen muscle and to produce activity in relation to the supporting surface

A *postural set* is an alignment of key points to each other in relation to an accepted base of support and reflects arrested movement. It provides an assessment of postural orientation. Used to describe the interrelationship between key points at a given moment in standing, sitting, supine, side lying and prone. A postural set provides a means of identifying the active connections between body segments in different postures and enables the therapist to develop hypotheses as to how the person has been moving / how they may attempt to move (Meadows & Williams 2009).

Through the *systematic analysis of a posture* we can assess:

- How one may move to or from a given posture
- The influence of gravity and awareness of the base of support
- The relationship of body parts to the base of support and to each other
- The influence of tone
- The development and evolvement of patterns of movement and their components
- The initiation of movement

Controlled movement comes from development of our phenotype and allows selective movement within the forces of gravity. The CNS and muscular systems are capable of making biochemical and structural changes in response to experience, training, inactivity and damage.

Key Messages

- There are wide tonal, postural and movement variations in the normal adult population
- What we do defines our systems, how frequently we do it refines them, which is reflected in the efficiency of motor performance
- Importance of understanding the potential for change

British Bobath Tutors Association
10 Main Street, Crawcrook, Gateshead, Tyne & Wear, NE40 4ND

E: enquiries@bbta.org.uk
T: 0191 580 0567
T: @BBTATutors
W: www.bbta.org.uk

Bibliography
Bernhardt J, Hill K. (2005) We only treat what it occurs to us to assess: the importance of knowledge-based assessment. In Refshauge K, Ada L, Ellis E (Eds) Science-Based Rehabilitation: Theories Into Practice. Elsevier.
Brown LA, Shumway-Cook A, Woollacott MH. (1999) Attentional demands and postural recovery: the effects of aging. J Gerontology 54a:M165-71.
Canedo A. (1997) Primary motor cortex influences on the descending and ascending systems. Prog in Neurobiology 51: 287-335.
Edwards, S. (2002) Neurological Physiotherapy: A Problem Solving Approach. Second Edition. Churchill Livingstone, London.
Fisher KM, Soteropoulos DS, Witham CL (2012) The motor cortex and descending control of movement. ACNR 11 (6); 11-13.
Felten DL, Jozefowicz RF (2003) Netter's Atlas of Human Neuroscience. Saunders.
Graham JV, Eustace C, Brock K, Swain E, Irwin-Carruthers S, (2009) The Bobath concept in contemporary clinical practice. Topics in Stroke Rehabilitation 16:57-68.
Horak FB. (2006) Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? Age and Aging 35(S2): ii7-ii11.
International Bobath Instructors Training Association (2008) Theoretical assumptions and clinical practice www.ibita.org pdf document.
Latash ML, Anson JG. (1996) What are normal movements in atypical populations. Behavioural and Brain Sciences 19:55-106.
Lemon RN. (2008) Descending motor pathways in motor control. Annu Rev Neurosci 31:195-218.
Lemon RN, Landau W, Tutssel D, Lawrence DG. (2012) Lawrence and Kuypers (1968a b) revisited: copies of the original filmed material from their classic papers in Brain. Brain 135(7):2290-2295.
Maki BE, McIlroy WE. (1997) The role of limb movements in maintaining upright stance: the change in support strategy' Physical Therapy 77:488-507.
Massion, J. (1994). Postural control system. Current Opinion in Neurobiology; 4:877–87.
Massion J, Alexandrov A, Frolov A. (2004) Why and how are posture and movement coordinated? Prog Brain Res 143:13-27.
Meadows L, Williams J. (2009) An Understanding of functional movement as a basis for clinical reasoning. In Raine S, Meadows L, Lynch-Ellerington ME (Editors) Bobath Concept*:* Theory and Clinical Practice in Neurological Rehabilitation*.* Oxford: Wiley-Blackwell pp23-42.
Raine S. (2007) The current theoretical assumptions of the Bobath Concept as determined by the members of BBTA. Physiotherapy Theory and Practice 23: 137-152.
Raine S. (2009) The Bobath Concept: developments and current theoretical underpinning. In Raine S, Meadows L, Lynch-Ellerington ME (Editors) Bobath Concept*:* Theory and Clinical Practice in Neurological Rehabilitation*.* Oxford: Wiley-Blackwell pp 1-22.
Schepens B, Drew T. (2004) Independent and convergent signals from pontomedullary reticular formation contribute to the control of posture and movement during reaching in the cat. Journal of Neurophysiology 92(4):2217-38.
Schmidt, RA., Wrisberg, CA. (2000) Motor Learning and Performance – A Problem Based Learning Approach. Second Edition. Human Kinetics, USA.
Shumway-Cook A, Woollacott M. (2011). Motor Control:Translating Research into Clinical Practice. Forth Edition. Williams and Wilkins, USA.
Sahrmann SA. (2002) Diagnosis and Treatment of Movement Impairment Syndromes. Mosby.

British Bobath Tutors Association
10 Main Street, Crawcrook, Gateshead, Tyne & Wear, NE40 4ND

E: enquiries@bbta.org.uk
T: 0191 580 0567
T: @BBTATutors
W: www.bbta.org.uk