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ORIGINAL ARTICLE

The Bobath concept – a model to illustrate clinical practice

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ABSTRACT

Background and purpose: The model of Bobath clinical practice provides a framework identifying the unique aspects of the Bobath concept in terms of contemporary neurological rehabilitation. The utilisation of a framework to illustrate the clinical application of the Bobath concept provides the basis for a common understanding with respect to Bobath clinical practice, education, and research. The development process culminating in the model of Bobath clinical practice is described.

Case description: The use of the model in clinical practice is illustrated using two cases: a client with a chronic incomplete spinal cord injury and a client with a stroke.

Discussion: This article describes the clinical application of the Bobath concept in terms of the integration of posture and movement with respect to the quality of task performance, applying the Model of Bobath Clinical Practice. Facilitation, a key aspect of Bobath clinical practice, was utilised to positively affect motor control and perception in two clients with impairment-related movement problems due to neurological pathology and associated activity limitations and participation restrictions – the outcome measures used to reflect the individual clinical presentation.

➤ IMPLICATIONS FOR REHABILITATION

- The model of Bobath clinical practice provides a framework identifying the unique aspects of the Bobath-concept.
- The model of Bobath clinical practice provides the basis for a common understanding with respect to Bobath clinical practice, education, and research.
- The clinical application of the Bobath-concept highlights the integration of posture and movement with respect to the quality of task performance.
- Facilitation, a key aspect of Bobath clinical practice, positively affects motor control, and perception.

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Introduction

The Bobath concept is currently defined as a problem-solving approach to the assessment and treatment of individuals with disturbances of function, movement, and tone due to a lesion of the central nervous system [1,2]. It is a concept that is inclusive and individualised, such that it can be applied to individuals of all ages and all degrees of physical and functional disability [1–4]. Bobath interventions are complex, multi-dimensional, response-based to the individual, and reflective [5]. Since its inception, the Bobath concept has focused on the recovery potential and motor performance of the individual [6]. Even though in the 1950's conventional treatment post-stroke comprised of a compensatory approach, the use, and strengthening of the less affected side, Mrs. Bobath recognised the ability to recover movement of the individual's more affected side, clearly deviating from traditional rehabilitation [6]. Advances in neuroscience, in terms of the strong evidence for neuromuscular plasticity, provides scientific evidence for the Bobath's foundational hypothesis which posited that recovery potential following a neurological lesion was possible [7,8]. Thus, within the Bobath approach, the potential for plasticity is recognised as the basis for skill acquisition and recovery within both neural and muscular systems [4].

The contemporary Bobath concept provides therapists with a conceptual framework to enable the development of an individualised intervention plan addressing complex movement challenges, i.e., it is not a series of treatment techniques, and as such differs significantly from interventions, such as body weight support treadmill training, functional electrical stimulation, rhythmic auditory stimulation, or constraint-induced movement therapy, none of which would be considered a comprehensive treatment programme, and are only applicable for patients with specific movement characteristics, or problems [5]. Treatment approaches, such as the "Motor Relearning Program" and "Task Orientated Training", like Bobath, are based on neuromuscular plasticity, a physiological process [9]. However, the use of structured task practice alone does not significantly improve motor function [10]. Within the Bobath approach sensorimotor re-training of meaningful tasks, with attention to underlying impairments, aims to promote plastic changes that are driven largely by repetition and temporal coincidence [7,11,12].

A key aspect of Bobath clinical practice since its inception is movement performance, i.e., "how" a task is completed, differing from Task Specific Training, where task completion is paramount, irrespective of whether the movement utilised is compensatory,

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atypical or typical [9,13]. Additionally, a consistent fundamental principle of the Bobath concept is the role of afferent input in motor control and perception to optimise body schema and influence task performance; as well as its importance for motor learning [14]. The Bobath concept considers facilitation, which includes therapeutic handling, modification of the environment, and appropriate use of verbal cues (see later for further discussion), to be a key aspect of clinical practice [6,15–17].

A systems model of motor control emphasises that human motor behaviour is based upon a continuous interaction between the individual, the task and the environment, with movement resulting from a dynamic interplay between sensory, cognitive, and motor systems [18]. The systems approach to motor control, based originally on the work of Bernstein [19], provides the foundation of the current theoretical underpinning of the Bobath concept [2]. Likewise, Bernstein's systems approach to distributed motor control remains consistent with current motor control theories including, equilibrium-point theory, the principle of abundance, and the uncontrolled manifold hypothesis [19–22].

Today, the Bobath concept is underpinned by contemporary theories of motor control, neuromuscular plasticity, biomechanics, and motor learning providing a theoretical basis for the interpretation of posture, functional human movement analysis, and recovery post-central nervous system lesion [4].

Recently, the theoretical assumptions of the Bobath concept have been updated and published [2–4], however, despite the Bobath concept being the most widely used treatment approach in neurorehabilitation worldwide [6,9], to date, a clearly defined model of clinical practice has been lacking in the evidence base. As a result, the application of the Bobath concept in intervention studies investigating the effectiveness of the Bobath concept has likely varied widely and, in some instances, may have been misinterpreted and/or misrepresented [6,9].

The International Bobath Instructors Training Association (IBITA) is the international Bobath organisation uniting 257 Bobath Instructors across 32 countries. The IBITA recognised that the lack of a clearly defined framework of Bobath clinical practice limits relevant and appropriate research into the effectiveness of the Bobath concept. Additionally, a clearly defined framework of Bobath clinical practice would facilitate consistency in Bobath post-graduate educational courses worldwide.

Development of the model of Bobath clinical practice

The Education Committee is a standing committee within the International Bobath Instructors Training Association (IBITA) whose mandate is to provide the theoretical underpinning for clinical practice of the Bobath concept, to promote continuing professional development and to ensure the quality of course content by on-going curriculum review. The Education Committee of the IBITA is comprised of four members who are elected to the committee by the membership. The term of office is three years and each committee member can serve up to two consecutive terms. The Chair of the committee is a rotating position. Each year in September the IBITA holds its Annual Congress comprising two educational days and 1 day for its Annual General Meeting (AGM) in which rules, regulations and procedures are discussed and voted upon. Each IBITA instructor is required to attend an IBITA AGM once every four years. At the IBITA AGM in Helsinki in September 2008, the Education Committee, under the leadership of Susan Ryerson (Senior IBITA Instructor), was given the mandate to develop a model of Bobath clinical practice to address the identified gap in the evidence base. Over the period 2008–2013, the Education Committee worked on the development of a model, which was presented at each AGM and sought consultation of the IBITA membership (Figure 1). The model was revised accordingly based on member feedback. During the 2014 and 2015 Annual Congress, the model was presented by members and illustrated through the use of clinical cases.

The resulting Model of Bobath Clinical Practice is the clinical parallel to the Bobath theoretical assumptions [2–4]. The aim of the model is to identify the unique aspects of the clinical

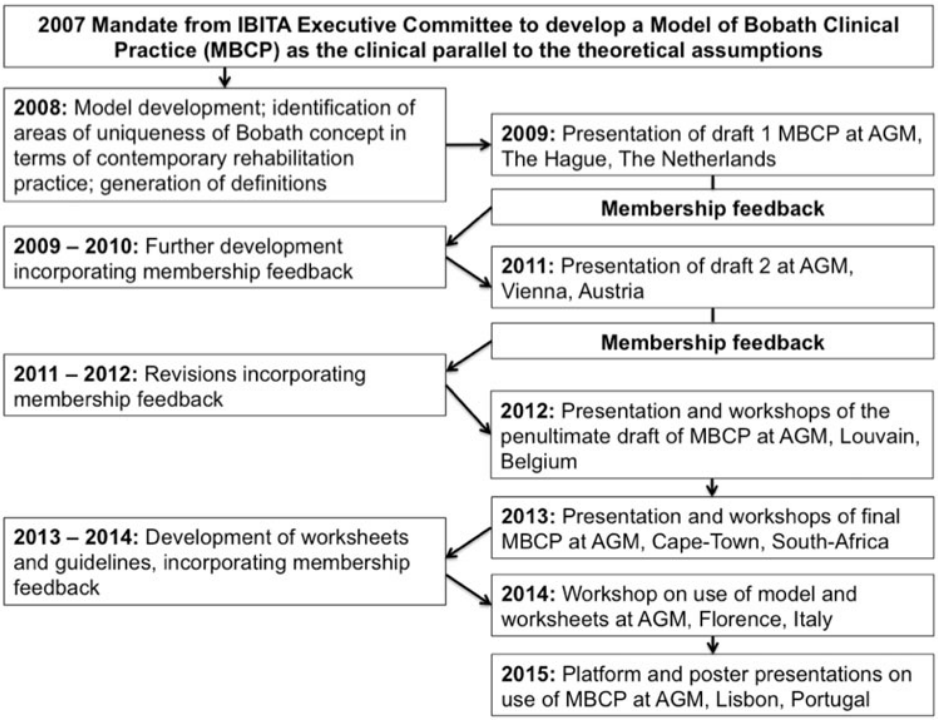


Figure 1. The development process of the model of Bobath clinical practice.

application of the Bobath concept and illustrate the interactive nature of its components within the context of contemporary neurorehabilitation. The model provides a framework to be utilised in clinical practice, education, and research.

The components of the model of Bobath clinical practice (MBCP)

The model (Figure 2) emphasises that the Bobath concept is inclusive and individualised, such that it can be applied to individuals of all ages, all degrees of physical and functional disability and is congruent with the International Classification of Functioning, Disability, and Health [4,23]. Optimising activity and participation require an understanding of the relationship between the client's health condition, personal factors, environmental, and individual contexts enabling the identification of meaningful functional goals [4,23].

There are three key components to the MBCP: (i) Functional movement analysis; (ii) Skilled facilitation; and, (iii) Clinical reasoning. Each component and related items are discussed below.

Critical cues are presented as a background to the key components of the model, highlighting that critical cues can arise from any aspect of the clinical interaction. Critical cues are aspects of the clinical presentation identified by the clinician as significant, thereby influencing the clinical reasoning process. Examples of critical cues may include but are not limited to: (i) aspects of malalignment; (ii) altered sequencing of movement patterns; (iii) musculoskeletal issues; (iv) a specific individual's response to facilitation; (v) client preferences; (vi) comorbidities; and, (vii) cognitive/perceptual issues. The interpretation of critical cues is a skilful, logical, and systematic process enabling the development of treatment hypotheses to guide the intervention plan.

Each component of the model will be discussed individually, however, in clinical practice, the components are integrated and utilised iteratively.

i. **Functional movement analysis**

Functional movement analysis within the model is a descriptive process of human movement of either an aspect of a task or the performance of a task within daily life. It comprises three specific units: (i) Postural control; (ii) Sensorimotor performance; and, (iii) Selective movement/sequences of movement.

The Bobath concept bases task analysis and intervention on an understanding of the integral relationship between postural control and sensorimotor performance, which requires selective movement for the production of coordinated sequences of movement [4,6,9,24]. Detailed observational analysis of sequences of movement during task performance determines how the movement differs from typical motor behaviour, including analysis of any compensatory strategies, and/or atypical motor behaviour utilised [6,9,14]. It is widely acknowledged that the central nervous system requires accurate, updated sensory information at all stages of movement to influence motor output [11,12]. Sources of sensory input include cutaneous, proprioception, and graviception (graviceptors are located in the large abdominal vessels and kidneys, and contribute to the perception of the postural vertical) [25–27], in addition to information from the vestibular and visual systems. Adequate and continuous information from all these sources builds and updates the body schema,

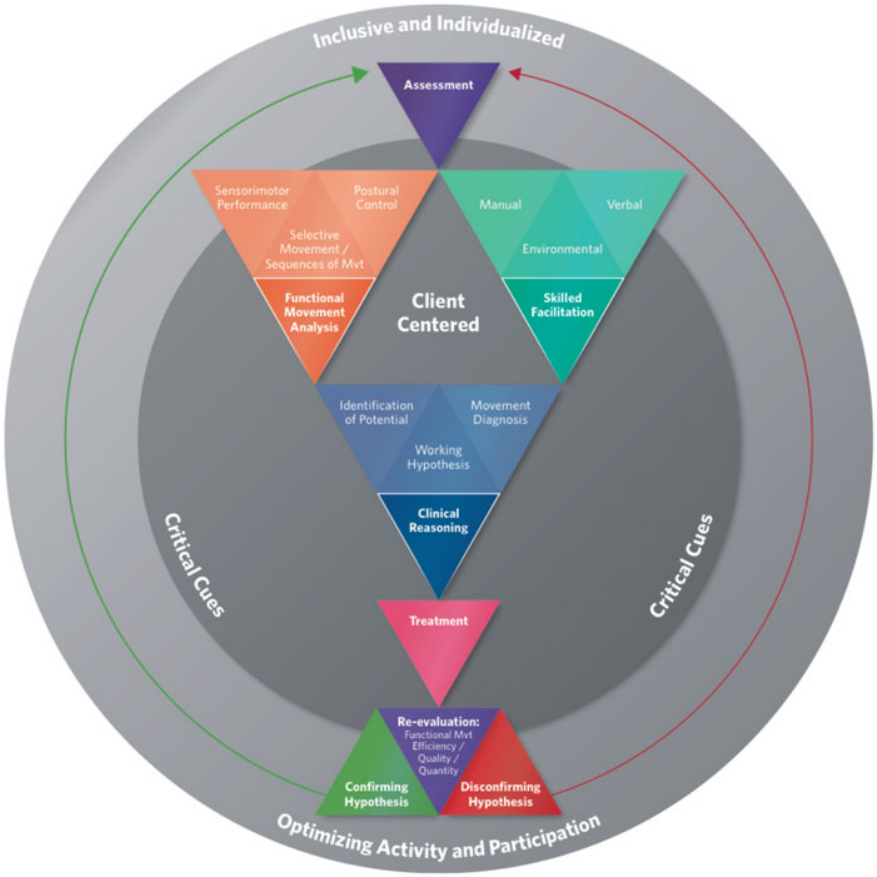


Figure 2. The model of Bobath clinical practice.

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which is of utmost importance for selective motor performance [28,29]. The therapeutic handling skill of the Bobath clinician influences the client's sensory flow and informs the therapist's movement analysis thereby contributing to the clinical reasoning process [14]. The MBCP considers not only task completion/assistance required, but also the quality, and efficiency of task performance as an integral aspect of assessment and on-going evaluation [6,9,24].

ii. **Skilled facilitation**

Facilitation has been a fundamental principle of the clinical application of the Bobath concept since its inception and is a unique aspect of the assessment and intervention process [4,6], it is used to make a task or movement possible. Facilitation is a clinical skill dependent upon the integration of the clinician's stereognostic capacity (the ability to interpret, integrate and execute therapeutic handling), and an extensive theoretical and professional practice knowledge base [4]. Facilitation comprises three specific aspects: (i) Manual; (ii) Verbal; and, (iii) Environmental and refers to the skilled interaction between the therapist and the client [14]. Therapeutic handling (e.g., handling the thorax during walking to improve body segment alignment and gait efficiency); manipulation of the environment (e.g., use of light touch as a balance aid in standing prior to stand-to-sit to achieve optimal sitting alignment); task selection (choosing a task which is meaningful to the client and context specific); as well as appropriate use of verbal cues (e.g., in relation to knowledge of result or knowledge of performance) are all taken into consideration in order to potentiate self-initiation/termination of movement and/or to create the necessary conditions for a movement experience that the client cannot yet do alone [14]. More examples are described in Vaughan-Graham and Cott [14].

iii. **Clinical reasoning**

Solving movement problems as a result of neurological pathophysiology requires an understanding of motor control and motor learning, neuromuscular plasticity, and functional human movement to optimise task performance. Within the MBCP, the clinical reasoning processes comprise three specific components: (i) Identification of potential; (ii) Movement diagnosis; and, (iii) Working hypotheses.

The clinician seeks to identify the potential of the client for positive functional recovery, whilst recognising the limitation of the neurological deficit. This is undertaken from the perspective of sensorimotor recovery, whilst minimising compensation strategies and atypical motor behaviour [14], recognising that recovery based on compensatory movement may limit the restoration of typical motor behaviour [24,30–34]. Identification of potential is dependent upon the interpretation of the client's positive and negative critical cues and is based on the current knowledge of neuroplasticity, prognostication, and the client's ability to motor learn. The Bobath clinician, whilst acknowledging the client's health condition and relevant restrictions, provides intervention based upon a movement diagnosis from which one or more working hypotheses are generated. The movement diagnosis is a compilation of the significant aspects of the functional movement analysis of the individual clinical presentation. Thus, the Bobath clinician does not treat the "neurological condition", but treats the individual impact of the neurological condition on the client from movement, perceptual, and cognitive perspectives. A working hypothesis or hypotheses guide the intervention plan with respect to postural control, task performance, selective movement, and sequences of movement. The working hypothesis/es and movement diagnosis are continually updated through a reflective in-action and on-action process, dependent upon the client's response to intervention and cue acquisition.

Bobath interventions seek to provide a rich source of afferent information to maintain, restore or update body schema such that feed-forward postural control and movement control are optimised (i.e., skilled facilitation). Interventions are evaluated from the perspective of quality/efficiency of the movement or task, i.e., formatively/diagnostically within a treatment session, as well as from a quantitative perspective, using validated, relevant outcome, and objective measures which demonstrate meaningful and significant clinical change [24]. Intervention and (re-) evaluation boxes lead to confirming and disconfirming clinical hypothesis/es. The arrows identify the iterative nature of the clinical reasoning process. Intervention aims to optimise activity, participation, and subsequent subjective quality of daily activities.

Clinical application of the MBCP

To facilitate the use of the MBCP in clinical practice and educational environments a worksheet and guidelines have been developed (Box 1). The worksheet provides a practical tool for instructors of the IBITA and clinicians, facilitating the integration of theoretical and professional practice knowledge to explicate the individual clinical presentation.

Clinical cases illustrating the MBCP

The MBCP is illustrated below (Boxes 2 and 3) in two different clinical scenarios: a teaching session on an IBITA Advanced Bobath Course and in a clinical practice situation. In both illustrations, the integration of posture and movement with respect to quality of task performance and facilitation is used to positively affect postural control and perception.

Clinical case 1

Patient A is a 58-year-old gentleman (Box 2, part 1: Personal factors) with a past medical history of a C6/7 incomplete spinal cord injury sustained in 1981. He presented with lower limb and truncal weakness, with occasional lower limb spasms, as well as low back and right knee pain (Box 2, part 2: Health condition). He lives with his wife and an adult son and is fully independent in all activities of daily living although reports his walking is effortful and restricted (Box 2, part 3: Environmental factors). He is right-handed, works as a freelance mechanic in his own garage and usual leisure activities include archery. He has recently recommenced outpatient physiotherapy and has identified his main goal as being able to walk longer distances, over uneven terrains, with less effort, and with reduced pain (Box 2, part 4: Patients goals). The following is an account of the initial assessment and physiotherapy intervention over three outpatient sessions using the MBCP as a framework.

Patient A was assessed moving independently between sitting, standing, and walking. Facilitation of gait, stand-to-sit and the transition into supine were used to inform the clinical reasoning process. Postural alignment in quiet stance and during an overhead reach task in standing was also assessed (Box 2, part 5: Tasks assessed). During the initial treatment session, selective trunk extension was explored in sitting with upper limbs placed with light touch support. Supine and side lying were also used to

Box 1. Guidelines of the Model of Bobath Clinical Practice

PERSONAL FACTORS	HEALTH CONDITION	ENVIRONMENTAL FACTORS
Are there specific individual personal data requiring consideration? e.g.: Age, gender, handedness, roles, occupation, routines,…	What specific medical issues need to be considered? e.g.: Diagnosis, date of onset, comorbidities, relevant medications, history of present condition, progression of pathological processes	Are there key facilitators and barriers impacting on activity and participation e.g. home, workplace, community access and support, assistive devices

CLIENT GOALS
Has the client identified specific goals? Do they require facilitation to identify achievable goals? Can an over-archin g goal with relevant sub- goals be identified in collaboration with the client?

FUNCTIONAL MOVEMENT ANALYSIS	CRITICAL CUES	SKILLED FACILITATION
Identify the relevant tasks that are assessed & what change has occurred as a result of the intervention - Stability task (stand, sit) - Mobility task (sit to stand, locomotion) - Manipulation component (sit and dress, ADL in standing including dexterity) e.g. What atypical or typical motor behavior does the client use to accomplish either an aspect of a task and/or the performance of a task/s with respect to sensorimotor performance, postural control, and coordinated se quences of movement.	What are the positive and negative significant aspects of this clinical presentation with respect to mvt analysis, facilitation, personal factors, health condition and environmental factors? e.g. Alignment, movement patterns, MSK issues, response to facilitation or lack of, client preferences, comorbidities, cognitive/perceptual strengths or weaknesses.	How does the client respond to specific manipulation of the environment, verbal cues and therapeutic handling? What additional information do you, the Bobath clinician, interpret from your therapeutic handling that informs your understanding of the client's presentation? e.g. Does a change to the environment influence motor behaviour? Does the client respond to specific verbal cues? How does therapist-controlled sensorimotor experience of movement influence the client's motor behaviour?

MOVEMENT DIAGNOSIS	WORKING HYPOTHESIS / HYPOTHESES	ENVIRONMENTAL FACTORS
Can you group the relevant characteristics of this client's clinical presentation to provide a summary with respect to their movement, perceptual and cognitive-attentional abilities? i.e. Relate the neurophysiology to the relevant impairments, activity limitations and participation restrictions which can be addressed therapeutically using the Bobath concept.	Can you identify 1-3 hypotheses based on the movement diagnosis, and with respect to client goals, which will guide the intervention plan ? e.g. Facilitation of Anticipatory Postural Adjustments via the corticoreticulospinal system first for Right Single Leg Stance, then Left Single Leg Stance will provide the required level of postural control for walking without a gait aid and reduce upper limb associated reaction.	Are there key facilitators and barriers impacting on activity and participation e.g. home, workplace, community access and support, assistive devices

TREATMENT
What postures were utilized in the treatment and why? How did these postures relate to the task or its component parts? Was the task broken down into components, and if so, what were the specific components? What specific therapeutic handling made a significant influence on the client's motor performance? How did the treatment address aspects such as restoration of body schema, sensorimotor integration, cognitive and perceptual deficits? What environmental modifications were utilized and why? Did the treatment address client identified goals, and if not, why not?

EVALUATION
How was the treatment evaluated formatively/subjectively within the treatment session? What outcome measures could be utilized from qualitative and quantitative perspectivesto provide comprehensive evaluation demonstrating clinically meaningful and significant change for the client, carer's and family members?

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Box 2. Clinical case 1 illustrated using the MBCP worksheet

<table>
<tr><td>Part 1: Personal factors:
58 year old right handed gentlemen; works as a freelance mechanic; usual leisure include archery</td><td>Part 2: Health condition:
History of a C6/7 incomplete spinal cord injury in 1981; currently presenting with a spastic paraparesis with truncal weakness, and bladder and bowel dysfunction; more recent history of back and knee pain.</td><td>Part 3: Environmental factors:
Lives with his wife and an adult son; fully independent in all activities of daily living although walking is effortful and restricted.</td></tr>
<tr><td colspan="3">Part 4: Patient goals:
Walking longer distances, over uneven terrains, with less effort.
Reduce back and knee pain (R > L).
To continue to participate in outdoor archery.</td></tr>
<tr><td colspan="3">Part 5: Tasks Assessed:
Quiet stance
Walking.
Stand-to-Sit and Sit-to-Stand.
Reaching in standing.</td></tr>
<tr><td colspan="2">Part 6: Functional movement analysis:
Sensorimotor performance: Critical cues
Reduced range of pelvic movement and weakness of the extensor multikinematic chain impacts on single leg stance, which affects both walking and reaching.
The preserved sensibility/proprioception enables independent qualitative practice.
The activated hand offers information through light touch in relation to postural control.
Postural Control: Critical cues
Stiffness and weakness limit the selective movement of the pelvis [hips and lumbar spine] for an adequate transfer of the Centre Of Mass above the Base Of Support and prevents appropriate anticipatory postural adjustments of the trunk and lower limbs for feed forward postural control.
Selective movement sequences: Critical cues
Inefficiency of single leg stance in gait limits contralateral swing limb advancement and reaching activity in standing.</td><td>Part 7: Facilitation:
Handling to realign lower limbs prior to facilitation of stand to sit; facilitation of selective trunk extension (multifidus and transversus abdominus) in sitting with upper limbs placed with light touch support, prior to the postural transition from sit to supine; in supine selective strengthening lower limb musculature and core; creation of crook lying with distal facilitation (foot); facilitation supine to side lying for further strengthening lower limb musculature; facilitation back into standing and stepping.
Manual Facilitation: Critical cues
Manual facilitation is essential for hip and pelvic biomechanical components, in order to reduce stiffness and to activate core musculature in a more selective way.
Verbal Facilitation: Critical cues
Understands verbal commands and translates these into appropriate motor behavior.
Environmental Facilitation: Critical cues
The environment is used to offer light touch as a balance aid and reduces the need for compensatory strategies.</td></tr>
<tr><td>Part 8: Movement diagnosis:
- Limited pelvic tilt, lower limb mal-alignment and extensor weakness impacts on antigravity competence that is crucial for functional walking.
- The absence of an efficient single leg stance limits stance stability and progression through stance and contralateral swing limb advancement
- Back and right knee pain related to mal-alignment of the lower right limb.</td><td>Part 9: Working hypothesis/ hypotheses:
- Increasing range of pelvic tilt to facilitate core and anticipatory postural adjustments of the trunk
- Scapula setting as a part of core training to reduce neck and shoulder over-activity.
- Improving lower limb alignment and strength as well as foot and calf activation will enhance ground reaction forces and propulsion.
- Improving right single leg stance and taking the first step with the left leg will more appropriately load the right lower limb in walking.</td><td>Part 10: Identification of potential:
- Handling improves alignment and postural control in a single session
- Sensorimotor performance improves with manual and verbal facilitation
- Environmental modifications and the use of light touch as a balance aid facilitate selective patterns of movement in the lower limbs during walking</td></tr>
<tr><td colspan="3">Part 11: Treatment:
Three consecutive treatment sessions of 1 hour.
Sequence of treatment included linear acceleration and lateral pelvic tilt to increase extensor activity and selectively guide the postural transition into supine; lower limb re-alignment and foot activation into crook lying with distal facilitation; core training in supine; facilitation into side-lying to strengthen lower limb extensor/abductor mechanism; core training in standing; scapula setting in prone standing; facilitation of a backward step; right single leg stance; facilitation of walking</td></tr>
<tr><td colspan="3">Part 12: Evaluation:
Quantitative evaluation
Functional Reach Test: pre 26 cm -> post 32 cm
Timed Up & Go Test: pre 38.60 sec. -> post 38.00 sec.
Visual Analogue Scale for back pain: pre 6/10 -> post 1/10
Visual Analogue Scale for right knee pain: pre 9/10 -> post7/10
Qualitative evaluation
Post treatment intervention reduced flexion, adduction and internal rotation of the hips in standing; more fractionated locomotor pattern and greater trunk stability; improved foot alignment with ankles as a reference point for the transfer for m standing into sitting; more selective reach pattern in standing without displacement of the trunk.

Part 13: Reflection and considerations for the treatment progression:
Residual stiffness in the lumbar spine and hip alignment impact on lower limb alignment and strength in standing and for the sit-to-stand transfer and the need for compensatory strategies: more work is necessary in this direction.
Weakness of the core (including scapulae) and postural instability of the feet is a very important element in the clinical presentation.
Pain (back and right knee) reduces in therapy, but increases as the quality of movement deteriorates in necessary function during the day.
Compensatory strategies decrease proportionally to the increase of postural stability.
Well motivated, ability to motor learn, good sensation, and the almost total absence of neural components are key strengths.</td></tr>
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Box 3. Clinical case: Use of MBCP in a client with a left Middle Cerebral Artery stroke

<table>
<tr><td>Part 1: Personal factors
40 year old right-handed lady; previously worked as an employee for a company designing lighting systems.</td><td colspan="2">Part 2: Health Condition
History of a malignant left middle cerebral artery stroke, with brainstem compression in July 2011, which required a left fronto-temporal decompressive craniotomy; currently presenting with right sided weakness, reduced balance mechanisms and aphasia.</td><td>Part 3: Environmental factors
Lives with her pre-teen daughter in a flat above her parents; independent in most activities of daily living but difficulty incorporating right arm and hand; drives a car; is able to use the telephone.</td></tr>
<tr><td colspan="4">Part 4: Patient goals
Walking for longer distances, with more confidence to carry out activities such as shopping, going out with her daughter in her spare time and being able to move more easily in crowds.
Using the right arm for simple daily activities.</td></tr>
<tr><td colspan="4">Part 5: Tasks Assessed
Quiet stance
Walking
Stand–to-Sit
Sit-to-Stand</td></tr>
<tr><td colspan="2">Part 6: Functional Movement Analysis:
Sensorimotor performance: Critical cues
- The potential to move the right arm is limited by soft tissue stiffness, secondary to an associated reaction in the upper limb.
- Functional walking and antigravity competencies are limited by weakness of the core and both the affected and unaffected lower limbs
- In performing movements, there is overreliance on visual input.
Postural Control: Critical cues
- The bilateral extensor deficit limits the transfer of the COM above the loaded feet.
- The dependency on visual input increases flexion and together with cortical control of walking limits the access to automatic processes for posture and locomotion.
Selective movement sequences: Critical cues
- The deficit of core control is the trigger for the associated reaction in the arm and of the increased right hip flexion in the swing phase, with subsequent foot inversion.</td><td colspan="2">Part 7: Facilitation: Eccentric mobilisation of forearm and wrist musculature to realign the upper limb in order to create light touch as a balance aid; selective trunk extension in sitting with upper limbs placed on a surface with light touch; use of the transition from stand to sit and from sit to stand to improve postural activity; facilitation of a backward step to reach terminal stance position and pre swing initiated from the foot; achieving right heel contact to facilitate single leg stance.
Manual Facilitation: Critical cues
- Structural stiffness can be reduced by eccentric mobilisation.
- Manual facilitation is essential for aligning biomechanical components in order to make complex sequences of movement possible and to reinforce these by repetition.
Verbal Facilitation: Critical cues
- The verbal command supports the manual one: comprehension is excellent despite aphasia.
- A verbal drive is useful to facilitate the rhythmic component of walking.
Environmental Facilitation: Critical cues
- Is able to maintain hand contact with the support, which enhances antigravity activity and reduces the degrees of freedom of movement to increase central stability.
- Environmental modifications improve postural orientation, and stability and reduce the associated reaction
- Thoracic extension reduces the visual dependency.
- Antigravity postural sets may be more effective in treatment.</td></tr>
<tr><td>Part 8: Movement diagnosis
- She maintains her antigravity position by thoracic hyperextension, which compensates for the deficit in core control in addition to the deficit of hip extension/abduction, with consequent associated reactions of the upper limb.
-Poor left single leg stance impacts on right swing phase; the right lower limb is “longer and heavier” and therefore more active flexion is required to limb advancement; this disadvantages the extensor system and contributes to inversion of the right foot.</td><td>Part 9: Working hypothesis/ hypotheses
- Reduced stiffness of the forearm and wrist musculature will facilitate hand contact and afferent input for body schema and feed forward postural control, enhancing postural orientation to the midline and stability.
- Improved hip / femoral alignment and more length in the hip flexors bilaterally will allow core activation.
- Selective extension of upper trunk and head/neck will reduce visual dependence for walking balance.
- More efficient single leg stance on the left, will improve left swing limb advancement.
- Improved right heel contact will facilitate appropriate extensor activity through the right multi-joint kinetic chain.</td><td>Part 10: Identification of potential
-During the treatment session demonstrated improved motor control performance whilst walking, characterised by:
i) Reduced associated reactions
ii) increased velocity and cadence.
iii) Reduced visual dependency
iv) Describes less effort required to walk.
v) Timed Up & Go Test: pre Rx - 26.54 sec; post Rx - 19.96 sec.
vi) 10 Meter Timed Walk Test: pre-Rx 10.50 sec; post-Rx 8.35 sec.

- Highly motivated.</td></tr>
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Part 11: Treatment:
One single assessment / treatment session carried out
Next session treatment progression to include:

(i) Soft tissue mobilisations to reduce structural tension of forearm, wrist and hand,
(ii) Use of light touch to facilitate postural orientation.
(iii) Facilitation of stand-to-sit increases eccentric extensor control.
(iv) Potential use of the postural set of reclined sitting to re-align the hips, activate the core and to prepare the right foot.
(v) Facilitated reach-to-stand through the right upper limb to load the foot and lengthen the right gastrocnemius and soleus.
(vi) Use of the postural set of prone standing to strengthen the trunk extensors; lengthen the right latissimus dorsi; work on scapula setting.
(vii) Facilitation of a backward step with the right leg, with the upper limbs placed at 90 degrees to increase trunk and lower limb extension, to gain length in the right calf as well as improve left single leg stance activity
(viii) Loading the right lower limb with heel contact to facilitate extension of the right leg in single leg stance.

Part 12: Evaluation:

Quantitative evaluation before and after treatment:
Timed Up & Go Test: 26,54 sec. -> 19,96 sec.
Timed Ten Meter Walk Test: 10,50 sec. -> 8,35 sec.
Qualitative evaluation before and after treatment:
Reduced visual dependence to walk; reduced associated reaction in the right upper limb; ability to access a more automatic gait pattern
Improvement of the following gait parameters: speed, step length, verticality of the trunk, associated reactions (upper limb and foot), dependency on visual control.
Weight transfer in sitting starting from the lower trunk and lower thoracic lateral tilt (L > R).
Higher activation of lower limbs during sit-to-stand and return with less anterior displacement of the trunk.

Part 13: Reflection and considerations for the treatment progression
The core is considered to be part of a multi-joint kinematic chain that extends from the feet ~~up~~ to the head, and the pelvic area is considered to be a key component.
In this patient weakness of the core strongly affects walking efficiency and is limiting the recovery of the upper limb.
The ipsilesional damage is very evident as a consequence of the hemispherical and brainstem involvement and this aspect must be considered in the therapeutic approach.
To influence the hypotonia effectively intensity will be required to achieve summation.
Walking at the end of the treatment session is faster, as evidenced by the 10 Metre Timed Walk Test, and on a more automatic level (CPG-activity).
A faster walk may in turn have beneficial effects on postural control mechanisms and potentiate more selective limb movement.
Targeted therapy for improved core control and strengthening can be preparatory for Body Weight Supported Treadmill Training with a minimum de-weighting of the trunk and lower limbs.

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activate and develop selective synchronous activation of the lower limbs and core musculature.

The following critical cues were identified in relation to sensorimotor performance, postural control and selective movement sequences (Box 2, part 6: Functional movement analysis):

- Sensorimotor performance: Reduced range of anterior and posterior pelvic tilt, and weakness in the lower limbs and core, impact on single leg stance [35]. This has the potential to affect both single limb support and swing limb advancement in walking, as well as reaching in standing. There is overuse of the upper limbs to aid propulsion in gait and compensatory overuse of the head to gain extensor activity. Lower limb spasms and biomechanical soft tissue changes are evident in supine. Sensation and cognition are both intact facilitating independent qualitative practice [36].
- Postural control: Spinal inflexibility, reduced range of movement at the hips and ankles, as well as trunk and lower limb weakness, impact on postural orientation and stability in sitting, standing and walking [29,37–40]. Reduced pelvic tilt affects the adequate transfer of the centre of mass with respect to the base of support in gait and during reaching. In standing, altered lower limb alignment (hip flexion/adduction/internal rotation and pronated feet) and poor interaction of the feet with the base of support influences anticipatory postural adjustments in the lower limbs and trunk [41]. The use of light touch support improves postural orientation and stability in standing and walking [42,43].
- Selective movement sequences: Impaired postural control mechanisms and inefficiency of single leg stance on either lower limb influences selective movement sequences during walking and reaching in standing [44–48].

Facilitation, both manual and verbal, and environmental modifications were used in the initial assessment to inform and update the therapist's clinical reasoning (Box 2, part 7: Facilitation):

- Manual: Realignment and facilitation of the stand-to-sit transition improve postural orientation in sitting. Mobilisation of the lumbar spine in sitting, facilitation of

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sit to supine via long sitting and activation of the core and lower limbs in both supine and side-lying improves sensorimotor performance and reduces pain in a single session [47–51].

- Verbal: Able to use verbal cues as a prompt and translate into appropriate sensorimotor behaviour.
- Environmental modifications: The upper limbs were placed with wrist extension on a vertical support to maintain trunk extension in sitting whilst mobilising the lumbar spine and exploring selective pelvic tilt. The feet were maintained in dorsiflexion in supine and side-lying whilst activating the core and lower limb musculature. The use of light touch as a balance aid when walking reduces compensatory strategies [42,52].

Identification of potential (Box 2, part 10): Based on the functional movement analysis and the response to facilitation the assessment highlighted that handling improves postural orientation and stability in sitting, standing, and walking; that sensorimotor performance (sit-to-stand/stand-to-sit and reach in standing) is changeable; and that the use of light touch as a balance aid facilitates more typical patterns of movement in the lower limbs during walking.

Movement diagnosis (Box 2, part 8): The main problems were identified as:

i. Spinal inflexibility and reduced range of movement of the hips;
ii. Lower limb mal-alignment (right greater than left);
iii. Reduced strength impacting on antigravity competence [35,47];
iv. Poor core control and single limb stance limiting stance stability, progression through stance, and swing limb advancement [44–46,48];
v. Back and knee pain related to mal-alignment of the lower limbs and trunk [53,54]; and,
vi. Compensatory strategies including overactive arm swing to aid progression of the centre of mass during walking, shoulder girdle elevation, head/neck extension, and trunk inclination during reach activity in standing.

The working hypotheses identified (Box 2, part 9) were:

i. Increasing the range of pelvic tilt will facilitate core control and anticipatory postural adjustments of the trunk and lower limbs [35,47,55,56].
ii. Scapula setting as a part of core control training will reduce neck and shoulder over-activity [57].

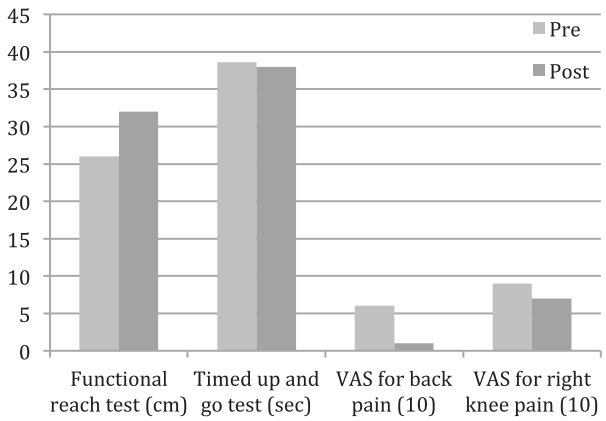


Figure 3. Pre-post treatment evaluation of clinical case 1.

iii. Improving lower limb and foot alignment and selective activation will optimise ground reaction forces, stability and propulsion in walking, and reduce compensatory strategies [49,58–61].
iv. Improving right single leg stance and taking the first step with the left leg will more appropriately load the right lower limb in walking and reduce low back and right knee pain [44–46,62].

The following outcome measures were selected to evaluate the working hypotheses (Box 2, part 12) (Figure 3):

Quantitative evaluation: (i) Functional reach test (FRT); (ii) Timed up and go test (TUG); (iii) Visual analogue scale (VAS) for back pain; and, (iv) VAS for right knee pain.

Qualitative evaluation: An observational analysis of the postural alignment in quiet stance and walking.

Treatment (Box 2, part 11):

Patient A received three treatment sessions each of 1-h duration. The sequence of treatment during each session included the following:

i. Improved linear extension of the trunk and lower limbs in standing through the facilitation of stand-to-sit as well as lateral pelvic tilt during the postural transition of sit to supine.
ii. In supine, the lower limbs were re-aligned and placed into crook lying with distal facilitation through the feet. The lower limbs were placed on a support with the hips and knees at 90° with the feet maintained in dorsiflexion during core control training.
iii. Side-lying was used to selectively activate the right lower limb hip extensor/abductor mechanism.
iv. Core training was also carried out in standing and scapula setting in prone standing.
v. Facilitation of a backward step in standing, facilitation of stand down into right single leg stance from a high surface, and facilitation of walking were also integrated into the treatment sessions.

Evaluation and re-evaluation (Box 2, part 12) (Figure 3):

Quantitative evaluation before and after treatment:

i. Functional reach test (FRT): pre 26 cm, post 32 cm
ii. Timed up and go test (TUG): pre 38.60 s, post 38.00 s
iii. Visual analogue scale (VAS) for back pain: pre 6/10, post 1/10
iv. Visual analogue scale (VAS) for right knee pain: pre 9/10, post 7/10

Qualitative evaluation before and after treatment:

After three treatment sessions the following qualitative aspects of movement were noted:

i. Reduced flexion, adduction, and internal rotation of the lower limbs in standing;
ii. Improved sequencing of the locomotor pattern;
iii. Improved trunk stability during gait;
iv. Improved foot alignment with the ankles as a reference point for the transfer from standing into sitting;
v. Improved selective reach pattern (improved straight-line pathway) in standing with decreased trunk displacement.

Reflection (Box 2, part 13):

Residual spinal inflexibility and reduced range of movement at the hips due to soft tissue restrictions impact on lower limb alignment and trunk extension in standing and during the sit-to-stand transfer. This necessitates the need for compensatory strategies, e.g., over-use and fixation with the upper limbs; therefore, further

treatment is required to address these movement problems. Decreased activation of the core (including scapula setting) and postural instability of the feet, due to reduced activation of the foot intrinsic musculature are important elements in the clinical presentation. Pain (back and right knee) decreased as a result of intervention but increases as the quality of movement deteriorates. Compensatory strategies decrease proportionally as postural stability improves. Patient A is highly motivated, has intact sensation and demonstrates the ability to motor learn. Musculoskeletal impairments appear to be a significant limitation whilst neuromuscular impairments appear to be related to lack of selectivity and sequencing.

Clinical case 2

Patient B is a 40-year-old lady (Box 3, part 1: Personal factors) with a medical history of a malignant left middle cerebral artery stroke, with brainstem compression, sustained in 2011. The brainstem compression required a left fronto-parietal decompressive craniotomy. Patient B is currently presenting with right-sided weakness, reduced balance, and aphasia (Box 3, part 2: Health condition). She lives with her pre-teen daughter in a flat above her parents. She is independent in most activities of daily living, although she has difficulty incorporating her right arm and hand. Patient B is able to use the telephone and drives her car (Box 3, part 3: Environmental factors). She previously worked as an employee for a company designing lighting systems (Box 3, part 1: Personal factors). Patient B identified her main goals as walking for longer distances, with more confidence to carry out activities, such as shopping, going out with her daughter in her spare time and being able to move more easily in crowds. Patient B would also like to be able to use her right arm for simple daily activities (Box 3, part 4: Patients goals).

The following is an account of a single outpatient session including initial assessment and physiotherapy intervention using the MBCP as a framework.

Patient B was assessed in quiet stance, walking and moving between standing and sitting. The transition from stand-to-sit and from sit-to-stand, as well as the facilitation of a backward step and single leg stance, was used to inform the clinical reasoning process. Selective trunk extension and creating light touch as a balance aid by realigning the right upper limb through mobilisation of the forearm and wrist musculature to gain eccentric lengthening of the arm (Box 3, part 5: Tasks assessed).

The following critical cues were identified in relation to sensorimotor performance, postural control and selective movement sequences (Box 3, part 6: Functional movement analysis):

i. Sensorimotor performance: Soft tissue stiffness limits the potential to move the right arm. Functional walking and standing balance are limited by reduced antigravity activity of the core and weakness of both the affected and unaffected lower limbs [50,63,64]. Patient B over relies on visual input in performing movements.
ii. Postural control: The bilateral extensor deficit through the lower limbs and trunk limits the transfer of the centre of mass above the loaded feet [64]. The dependence on visual input increases truncal flexion and together with cortical control of walking negatively impacts on the ability to achieve appropriate postural responses and a rhythmical gait pattern [41,65].
iii. Selective movement sequences: The impaired core control results in an associated reaction of the right arm [47], as well as increased right hip flexion during the right swing phase with associated right foot inversion [66].

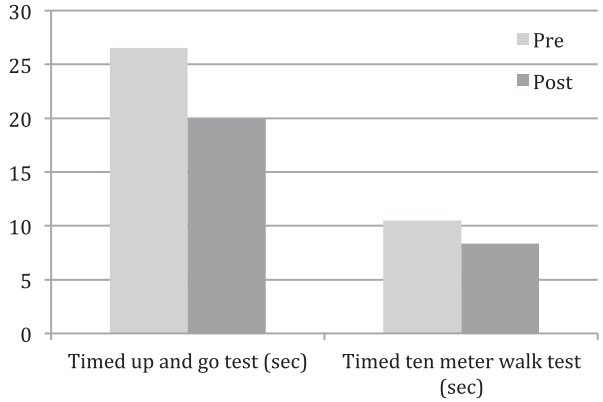


Figure 4. Pre-post treatment evaluation of clinical case 2.

Facilitation, both manual and verbal, and environmental modifications were used in the initial assessment to inform and update the therapist's clinical reasoning (Box 3, part 7: Facilitation):

i. Manual: Structural stiffness of the soft tissues of the upper limb reduced with soft tissue mobilisation. Manual facilitation is essential for aligning biomechanical components in order to make complex sequences of movement possible and to reinforce these by repetition [29,41].
ii. Verbal: Despite Patient B's aphasia, her comprehension is excellent and verbal commands are used to support the manual facilitation. Verbal feedback is used to facilitate the rhythmic component of walking.
iii. Environmental: Environmental modifications are used to improve postural orientation and stability and to create light touch as a balance aid, as such limiting the degrees of freedom of movement thereby improving postural stability [42,43,67–69].

Identification of potential (Box 3, part 10): Patient B is highly motivated and demonstrated improved motor control performance whilst walking during the assessment/treatment session.

Movement diagnosis (Box 3, part 8): The main movement problems identified were:

i. Thoracic hyperextension, as a compensation for the deficit of core control and impaired anticipatory postural control.
ii. Reduced right hip extensor/abductor mechanism, with consequent associated reactions of the right upper limb.
iii. Active flexion of the right lower limb during swing phase due to poor left single leg stance.

The working hypotheses identified (Box 3, part 9) were:

i. Reduced stiffness of the forearm and wrist musculature will facilitate hand contact and afferent input for updating body schema and feed-forward postural control, enhancing postural orientation to the midline and stability [42,43,67–69].
ii. Improved hip/femoral alignment and increased soft tissue length in the hip flexors bilaterally will positively affect posterior pelvic tilt thereby potentiating improved core activation [64].
iii. Selective extension of the upper trunk and head/neck will reduce visual dependence for walking balance [70,71].
iv. Improved efficiency of left single leg stance will positively affect right swing limb advancement.
v. Improved right heel contact will facilitate appropriate extensor activity through the right multi-joint kinetic chain [45,46].

The following outcome measures were selected to evaluate the working hypotheses (Box 3, part 12) (Figure 4):

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Quantitative evaluation: (i) Timed up and go test; and, (ii) Timed 10-m walk test,

Qualitative evaluation: Observational analysis of gait parameters, sitting balance, and sit-to-stand.

Treatment (Box 3, part 11):

Patient B received one single assessment/treatment session including the following interventions:

i. Soft tissue mobilisations to reduce structural tension of the forearm, wrist, and hand.
ii. Use of light touch to facilitate postural orientation [42,43,67–69].
iii. Facilitation of stand-to-sit to improve eccentric extensor control. Use of the posture of reclined sitting to re-align the hips, activate the core, and to mobilise the right foot to improve foot to floor interaction.
iv. Facilitation of reach-to-stand through the right upper limb to load the right foot/heel and gain eccentric length of the right gastrocnemius and soleus.
v. Use of prone standing to activate the trunk extensors against gravity, to gain length in the right latissimus dorsi, and to activate scapula setting.
vi. Facilitation of a backward step with the right leg, with the upper limbs placed at 90° to facilitate trunk and lower limb extension, gain length in the right calf, and to improve left single leg stance activity. Optimal loading of the right lower limb with heel contact to facilitate selective extension during right single leg stance.

Evaluation and re-evaluation (Box 3, part 12) (Figure 4):

Quantitative evaluation:

i. Timed up and go test (TUG): pre 26.54 s, post 19.96 s
ii. Timed 10-m walk test: pre 10.50 s, post 8.35 s

Qualitative evaluation before and after treatment:

i. Improvement of the following gait parameters was observed: speed, step length, verticality of the trunk, decreased associated reactions (upper limb and foot), and reduced dependency on visual control.
ii. Weight transfer in sitting starting from the lower trunk and lower thoracic lateral tilt (left > right).
iii. Improved selective activation of lower limb extension during sit-to-stand and eccentric control during stand-to-sit with decreased anterior displacement of the trunk.

Reflection (Box 3, part 13):

The core is considered to be part of the multi-joint kinematic chain extending from the feet to the head, and core control is essential for the position and movement of the trunk for optimal production, transfer, and control of forces to and from the limbs [72]. In this patient decreased activation of the core strongly affects walking efficiency and limits the recovery of the upper limb. The ipsilesional damage is very evident as a consequence of the hemispheric and brainstem involvement and this aspect must be considered in the therapeutic approach [73].

To influence the decreased activation effectively, intensity will be required to achieve summation and thus carry over between treatment sessions.

Walking time following treatment was faster, as evidenced by the 10-m timed walk test. Patient B's walking pattern appeared to be less cognitive and more rhythmical. A faster walk may in turn have beneficial effects on her postural control mechanisms and potentiate more selective limb movement [53]. Targeted therapy for improved core control and sustained anti-gravity activity, specifically the facilitation of single leg stance, may be preparatory for body weight supported treadmill training with minimum de-weighting of the trunk and lower limbs.

Insert Box 3: Clinical case 2: Use of MBCP in a client with a left middle cerebral artery stroke.

Conclusion

This article identifies the key aspects of Bobath clinical practice, illustrated through two clinical cases with respect to the current neuroscience and neurorehabilitation evidence-base. The MBCP is the clinical parallel to the updated theoretical assumptions published by Vaughan-Graham et al. [4].

The clinical examples demonstrate how the MBCP can be utilised to articulate the assessment process whilst documenting the interventions and simultaneously integrating the evidence base. The worksheet with accompanying guidelines was developed to facilitate the use of the MBCP in clinical practice and research.

It is anticipated that the MBCP will be used as a basis for future research to ensure the application of the Bobath concept reflects current clinical practice. The MBCP has recently been included into the IBITA core curriculum for a Basic Bobath course (AGM South-Korea, September 2016) to explicate the clinical application of the Bobath concept thereby ensuring consistency in IBITA courses taught worldwide.

Disclosure statement

The authors report no declarations of interest.

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