Neuro-Developmental Treatment (NDT) and Neurological Disorders: The Latest Research and Resources for OTs and PTs

(2 CEs)

Learning Objectives

- Summarize foundational theories and treatment behind NDT.
- Explain what NDT looks like as delivered through physical and occupational therapy practitioners.
- Summarize current peer-reviewed NDT research.
- Identify and describe NDT-appropriate neurological disorders outside of cerebral palsy (CP) and hemiplegia.
- Identify updated resources for proper billing of NDT in specific practice settings.
- Discuss current therapy resources for NDT to enhance the clinical practice.

Introduction

Neuro-developmental treatment (NDT) also referred to as the Bobath Concept or approach, has been around since the 1940s when it was first developed by Berta and Dr. Karel Bobath. Initially, the Bobaths introduced innovative therapeutic approaches for children with cerebral palsy and adults with hemiplegia.

Today, NDT is widely used in the therapy realm for numerous neurological conditions and has revolutionized hands-on clinical work. Physical and occupational therapists working in various settings and capacities worldwide have incorporated NDT principles and practices into their patients' treatment sessions.

Like other theoretical and practical roots of physical therapy and occupational therapy, NDT's foundations have aged; this, however, does not mean that NDT is less applicable or is out-of-date. As with other treatment theories, NDT was designed to evolve as clinicians learned more about the human function. In fact, the Bobaths insisted that NDT must be applied so that it could evolve over time in order to fully understand the recovery of function in neurological conditions (Runyan, 2006).

As new treatments take the limelight, however, older treatment approaches are at risk of fading. This fading occurs because therapists forget their foundations, neglect educational opportunities, and avoid active participation in empirical research. Without rejuvenating and continuously supporting NDT, therapists may dismiss its effectiveness with patients who strongly benefit from its approach; further, funding for coverage is questioned.

The following course includes the latest resources and research available for physical and occupational therapists regarding NDT. Additionally, this course is a call to action for therapists to offer up their support in order to maintain the reliability and validity of NDT in both its foundational principles and its progression.*

*****Note: This course is an overview of NDT foundations, principles, and practices. The following information is not a replacement course for the NDT/Bobath Certification course, or for advanced certification courses. If you are interested in obtaining certification through the intense training seminars, please visit the following site: http://www.ndta.org/ndt-certification.php.

Review of NDT foundation and theory

The Bobaths: Founders of NDT

Before becoming a physiotherapist, Berta Busse was a skilled masseuse and a gymnastic instructor in London. It was during her time in London that she reconnected with her old friend, Dr. Karel Bobath. Karel had spent most of his early medical practice in general pediatrics and pediatric surgery. They were married in 1941.

In the following years, Berta began to piece together a new treatment for spasticity, which we now know as the "Bobath Concept" or "NDT." Together, Berta and Karel spent the rest of their lives teaching clinicians around the world about the Bobath Concept and its applications to neurological conditions (Bobath Centre, 2018).

The Bobath Concept

The Bobath Concept was created in order to address sensorimotor impairments in persons with neurological conditions. During the time when the Bobaths were first piecing together their treatment approach, the poliomyelitis outbreak was occupying much of the orthopedic and therapy world. Polio survivors were left with abnormal muscle tightness and/or weakness, which therapists usually treated with bracing, therapeutic exercise, and muscle re-education.

After polio was virtually eradicated with the introduction of its vaccine, therapists were using the same muscle treatments on individuals with hemiplegia and cerebral palsy. Unfortunately, therapists and physicians were not achieving productive results with these treatments (Howle, 2002).

Additionally, it was assumed that muscle conditions due to cerebral palsy or post-stroke were permanent. As a result, clinicians would teach their patients how to compensate for their muscle loss, rather than attempt to restore movement to the affected muscles (Runyan, 2006).

Berta Bobath identified that although patients with cerebral palsy and hemiplegia had observable muscle tightness and atypical movement, these patients also had a "disorder of coordination in posture and movement" (Bobath, 1953 as cited by Howle, 2002, pg. xvi). This disorder occurred due to a lesion or damage to the central nervous system and resulted in atypical movement that severely reduced functional participation. Furthermore, it was discovered individuals with such disorders in movement could recover and go back to their functional tasks.

So, let's go back and simplify the aspects of the Bobath Concept. The following points are what Berta Bobath identified as unique assumptions about atypical movement, which outlined the basic principles of the Bobath Concept:

1. Muscle weakness or tightness in hemiplegia and cerebral palsy was a direct result of lesions or damage to the central nervous system (CNS).
2. Individuals with cerebral palsy and hemiplegia had a disorder of posture AND movement.

3. Atypical movement as a result of damage to the CNS had the potential to recover.

Children with cerebral palsy

Cerebral palsy refers to a group of disorders in which developmental disturbances occur in the central nervous system. Such disturbances usually occur prenatally or in newborns and can include sensation, perception, cognition, communication, and behavior, by epilepsy, and by secondary musculoskeletal problems (Rosenbaum, 2006 as cited by Antilla et al., 2008).

Berta Bobath suggested that children with cerebral palsy could lengthen and strengthen muscle tissue in order to perform functional tasks through the use of guided movements (Barthel, 2010). Her approach challenged then-current assumptions that movement challenges experienced by children with cerebral palsy were reflexive in nature. With the assistance of the Bobaths as well, as other clinicians expanding NDT, researchers have since found cerebral palsy to be more diverse and complex.

The definition and classification of cerebral palsy has drastically expanded since the Bobaths initially began their work: much more is known about the subtypes and combinations of atypical movement. The least complicated description of cerebral palsy incorporates a scale between "mild and severe." For more accurate descriptions, the following terms are used (Cerebral Palsy Foundation, 2018):

Limbs affected:

- Monoplegia (one limb affected);
- Diplegia (two limbs, usually the legs, more affected than the arms);
- Triplegia (three limbs affected);
- Hemiplegia (one side of the body affected);
- Double hemiplegia (both sides affected, but one side more severely affected);
- Tetraplegia (four limbs affected); or
- Pentaplegia (four limbs affected plus neck and head).

Spasticity:

- Pyramidal (spastic);
- Extrapyramidal (non-spastic); and
- Mixed (both spastic and non-spastic).

Spastic cerebral palsy compromises about 80% of CP cases in which movement patterns appear stiff and jerky due to increased muscle tone. Spasticity is a result of damage to the motor cortex of the brain. Additionally, the tightening of muscle tissue causes increased flexion at the joints (i.e. elbows, wrists, fingers, hands, knees, etc.) (Cerebral Palsy Alliance, 2018).

Non-spastic cerebral palsy can be broken down into two subtypes: ataxic and dyskinetic:

- **Ataxic** cerebral palsy is an absence of involuntary movements, but there clearly is irregular motor coordination present.

- **Dyskinetic** cerebral palsy includes two more divisions: athetoid and dystonia. Athetoid includes involuntary movements in one or more of the limbs; dystonia primarily affects the trunk muscles (Cerebral Palsy Foundation, 2018).

No matter the type of cerebral palsy, it has become clear that atypical movement from this disorder wreaks havoc on a child's (or adult's) ability to complete functional tasks such as ambulation, bed mobility, toileting, dressing, basic hygiene, self-feeding, or any other daily tasks that are meaningful to the person affected.

It is important to note that the detailed classifications of cerebral palsy support NDT's stance that treatment should be a highly individualized approach in order to recover movement (this concept will be further discussed later in the course).

Adults with hemiplegia

The Bobath Concept has heavily influenced today's therapy practices in regard to treating patients with hemiplegia post-CVA (cerebral vascular accident). As with cerebral palsy patients, patients with hemiplegia experience atypical movement and muscle loss due to CNS damage after a stroke.

First, let's clear up some confusing definitions. When discussing foundational information about NDT, the literature states that the Bobaths worked with adults with "hemiplegia." Today, there are accepted differences between the terms "hemiplegia" and "hemiparesis." Hemiplegia translates to full paralysis of one side of the body; hemiparesis means partial paralysis or partial loss of movement on one side of the body (Stroke-Rehab.com, 2018). Whether it is full or partial paralysis, both conditions can be addressed using NDT techniques.

Types of hemiplegia have been classified in multiple systems, which has made the labels confusing to many therapists. From a rehabilitation standpoint, OTs and PTs will often use the terms "hypertonicity" and "spasticity" interchangeably. *Hypertonicity* of muscle tissue describes an increased resistance to passive movements of affected joints. Two subtypes of hypertonicity are spasticity and rigidity. Spastic hemiplegia creates "exaggerated tendon jerks, resulting from excitability of the stretch reflex" (Davies, 2000, p. 61).

In some cases of hemiplegia, muscle tissue takes on a hypo-toned appearance, causing the affected side of the body to go flaccid. In both cases of hyper-toned and hypo-toned muscle tissue, voluntary movement of the affected side becomes drastically reduced, thus causing severe limitations in carrying out functional tasks.

There are several post-stroke conditions that make functional recovery challenging for patients with hemiplegia; paralysis of muscle tissue is not the sole barrier to be met in the rehabilitation process. Depending on the type and severity of the stroke, patients are potentially dealing with loss of sensation, join laxity (subluxation), hyper-tonicity/hypo tonicity of muscle tissue, acute/chronic pain, visual field and perceptual deficits, cognitive issues, postural misalignment, and lack of trunk control (stroke.org, 2018).

According to the Brunnstrom Approach (a related theoretical/practical approach to hemiplegia), there are six stages of recovery for hemiplegia:

- Stage 1: The patient is completely flaccid, no voluntary movement;
- Stage 2: Basic limb synergy develops, no voluntary movement, spasticity appears but is not marked;
- Stage 3: Basic limb synergy develops voluntarily and is marked, spasticity is marked;
- Stage 4: Spasticity begins to decrease, four movement combinations deviate from basic limb synergies and become available;
- Stage 5: There is relative independence of the basic limb synergies. Spasticity is waning, and movements can be performed;
- Stage 6: There are isolated joint movements (Sawyer & La Vigne, 1992).

These six stages provide a basic outline for expected recovery in hemiplegia, but the level of recovery varies by individual (i.e. partial, full, or no recovery of affected movement) due to other post-stroke conditions (as previously mentioned).

For example, a post-stroke patient with severe cognitive impairments may be completely dependent on others for joint movement because the patient lacks the ability to initiate and to re-learn functional movement. For others, the recovery of functional movement may occur over time.

In 1972, Dr. Michael Newman conducted a research study* with 39 patients from the Manitoba Rehabilitation Hospital. All subjects were post-stroke with hemiplegia, had no serious medical complications, and were transferred to Manitoba within four weeks from initial onset.

All but five subjects recovered the functional use of their affected sides. The majority of the subjects were able to recover 80% of their functional abilities by the end of six to 14 weeks. Further, there were very rare instances in which remarkable neurological recovery was made after 12 weeks (Newman, 1972, pg. 705).

*Note: This study was able to identify what recovery looks like for post-stroke hemiplegia in the absence of a specific treatment.

Let's now take a look at a similar study that was conducted in 2015 by Kyoung Bo Lee and his colleagues. This team conducted a longitudinal follow-up study that spanned over a 20-month period. By the end of the study, 20 participants fully met the criteria and follow-up requirements to be included in the study. One of the priority requirements was that the participants were post-stroke with functional motor deficits lasting longer than two weeks after initial onset.

Several standardized evaluations were performed by physiotherapists to assess subjects' "motor and sensory function, cognition, walking, and functional recovery after stroke" (Kyoung, 2015). The greatest degree of recovery occurred four weeks after initial stroke in all assessed areas, with some variability. Further recovery was observed between three to six months, contradicting previous studies that state that very little recovery was made during that time frame (Duncan and Lai, 1997; Verheyden et al., 2008 as cited by Kyoung, 2015). As with Dr. Newman's study, Kyoung et al. (2015) did not reveal the details behind the physiotherapy and occupational therapy interventions that were provided for the study's participants.

When NDT came to America

"The Bobath Approach" or the "Bobath Concept" are terms used primarily by clinicians outside of the United States to describe this treatment. Neuro-developmental treatment (NDT) was coined by the Bobaths while they were in the U.S. because they were encouraged to not use their own name to describe the treatment approach (Runyan, 2006).

NDT supports the assumptions behind "neuroplasticity," an innovative theory introduced in the 1990s that states that the central nervous system (CNS) "has the ability to shape and/or renew itself in response to practiced activities" (Runyan, 2006). For the last several years, further research has revealed that approaches such as NDT support neuroplasticity because of heavy involvement of the affected side in therapy, which promotes healing of the CNS lesions.

There are three elements that make NDT stand apart from other treatment approaches:

1. **Alignment of body segments:** Berta Bobath found that aligning the body improves postural control, thus allowing persons with hemiplegia to actively use the affected side of their body (Runyan, 2006). This is where that well-known "90-90-90" position comes into play. For example, if a child wanted to color a picture at a desk, the therapist would have the child sit with his/her knees at a 90-degree position, the hips at a 90-degree position, and the feet/ankles at a 90-degree position.

2. **Twenty-four-hour management:** The Bobaths emphasized the importance of teaching patients, family members, and caregivers about managing affected extremities outside of therapy sessions. Carryover of learned techniques outside of sessions promoted increased functional recovery.

3. **Physical handling:** Although handling or providing physical/tactile cues isn't necessarily unique to just NDT, the methods behind handling are. The key to using physical handling is to provide manual cues to access missing components of movement, instead of fulfilling the movements for them in order to complete functional tasks (Runyan, 2006). Too much handling would prevent the affected individual from learning new movements in order to recover function.

According to Runyan (2006), there are six principles of NDT management:

1. **Individualize functional outcomes:** Interventions should consist of activities and strategies specific to the patient's needs, based on both the patient's unique limitations and his/her functional goals.

2. **Emphasis on motor control:** Choose therapeutic activities that encourage the client's active participation in order to promote both problem-solving and active use of muscles. This means getting past the redundant use of an Omni-cycle or a Nu-step. The activities should be meaningful to the patient as well as give them a chance to learn novel movements.

3. **Increase active use of the affected or involved side:** Find opportunities to involve the affected side in intervention activities, even if this means filling in the movement gaps with physical handling techniques.

4. **Provide practice:** Allow the patient to practice and repeat activities in order to refine and recover movement.

5. **Teach 24-hour management:** As mentioned previously, provide education in order to carry over learned tasks during therapy to other parts of the patient's day.

6. **Use and interdisciplinary approach:** Involve all relevant rehabilitation disciplines (OT, PT, and SLP) and ensure the carryover of NDT techniques (p. 774).

What NDT treatment looks like in the OT and PT clinical settings

NDT is applicable in an endless variety of settings: schools, inpatient care, acute care, skilled nursing, transitional care, early intervention, home health, outpatient, and community-based settings. As a direct result, NDT can be used for any person whose functional movement has been affected by a neurological-related condition. Physical and occupational therapists who use NDT within their patient's plan-of-care are also combining their unique discipline approaches. This means that NDT-based treatments may look similar, or vastly different, between OT and PT settings.

In order to minimize confusion, the following case studies have been developed to represent what simplified NDT could look like in a PT session, an OT session, and a co-treatment session involving both disciplines:

PT session:

Sarah is a physical therapist who has been working in a transitional care unit for three years. Two weeks ago, she evaluated Gordon—a 49-year-old male patient who suffered a left-side embolic stroke. As a result, he has right-side hemiplegia with an observable flexor synergy pattern and palpable hypertonicity throughout his right upper and lower extremities. Since the stroke, the patient has regained some voluntary movement on his hemiplegic side, but has drop foot and limited L. hip flexion. At initial evaluation, Sarah determined that the patient was able to ambulate with a walker up to five feet at a time with minimal assist. The patient's goal is to be able to climb his five-step entryway in order to enter his house.

Gordon tried the gym stairs for the first time today. He was able to ambulate to the first step with a walker and a R. foot AFO. Sarah used NDT-based handling techniques to help Gordon facilitate L. hip flexion in order to clear each step safely. As treatments continue, Sarah is hoping to reduce the hands-on facilitation while at the steps and with other PT exercises (which she assigns Gordon for outside-gym use) that require voluntary L. hip flexion.

OT session:

Karen is a home-health OT who has been working with Miles, a 4-year-old boy with spastic cerebral palsy. Miles and his mother want him to be able to feed himself successfully with a spoon, but he has trouble coordinating spoon use with his hands. Although there is present spasticity, Miles is able to grasp small objects in his right hand. During self-feeding sessions, Karen was able to determine that Miles has difficulty with extending his elbow to scoop and flexing his shoulder to bring the spoon to mouth. Over

the course of several treatment sessions, Karen has applied physical handling techniques to facilitate voluntary elbow and shoulder flexion for self-feeding. Since Karen can only visit Miles four times a month, she designed a treatment schedule and educated his mother on handling techniques that can be used for self-feeding, as well as for other daily living tasks.

OT and PT co-treatment:
Jill is a 39-year-old female patient who suffered a hemorrhagic stroke three weeks ago. As a result, Jill has L. side hemiplegia and global aphasia, rendering her completely dependent on others for bed mobility, transfers, and ADLs. After completing their initial assessments at a skilled nursing facility, Landon (PT) and Clint (OT) determined that therapy would best benefit Jill if it was provided through co-treatment sessions. Jill's husband, David, states that is essential for Jill to be able to get in and out of bed on her own and to complete her own transfers—either with or without the assistance of medical equipment: David was in a work accident six years ago and due to a severe back injury he is unable to lift Jill.

Landon and Clint each develop a plan-of-care for Jill. They focus on specific goals so that their documentation does not overlap. Landon makes bed mobility and standing balance priority goals; Clint focuses on sitting balance and upper extremity use in order for Jill to complete transfers and toileting tasks.

Because Jill requires total assist for bed mobility, their first few sessions with Jill require a lot of physical handling. While Clint focuses on facilitating affected upper-extremity movements and trunk control, Landon facilitates lower extremity involvement and guides Jill through bed mobility rolling, pulling up to a seated position, planting her feet, and participating in edge-of-bed functional tasks (hygiene and dressing).

As Jill recovers movement, bed mobility progresses to standing and transferring to a wheelchair to access the bathroom. Furthermore, as Jill progresses, Clint and Landon keep both the nursing staff and the CNAs in the loop about what she can do on her own, as well as how they can facilitate independent movements outside of therapy.

Although there is so much more that NDT can do in these case studies, all three scenarios demonstrate the highlights of what makes NDT unique:

- Individualizing functional outcomes or goals for each patient based on what they want to accomplish and what their unique movement limitations are;
- Emphasizing motor control and allowing the patient to problem-solve their own movements, involving the affected extremities;
- Providing practice by repeating the motions every session;
- Allowing for 24-hour management by the individual themselves (as well as with the help of others); and
- Calling on other disciplines for assistance to create a holistic treatment approach.

Summary of peer-reviewed evidence

Since the Bobath/NDT approach has been around since the 1940s, it would not be great use of this course to include ALL empirical evidence regarding its effectiveness. Instead, the following information is a synopsis of selected peer-reviewed articles pertaining to NDT as it was applied to certain participants in the last 10 years. Furthermore, the summary of information has been separated into two sections: NDT as a stand-alone intervention, and NDT combined (or compared with) other rehabilitative interventions.

NDT as a stand-alone intervention

NDT-based therapy programs will address functional movements that revolve around postural control and alignment: without it, unsupported movement does not work. This automatically includes any of the following functional movements and transfers:

1. Head control;
2. Rolling (supine<->sidelying<-> prone);
3. Crawling;
4. Sitting unsupported;
5. Functional reaching of the arm;
6. Quadruped positioning;
7. Kneeling;
8. Standing unsupported;
9. Side-lying to sitting;
10. Sit-to-stand transfers;
11. Stand pivot transfers;
12. Ambulating;
13. Jumping;
14. Running.

Arndt et al. (2008) assessed the efficacy of an NDT-based sequenced trunk activation protocol used for infants. Participants in this assessment included infants from ages four to 12 months with gross motor delays, as were identified by the AIMS (Alberta Infant Motor Scale). Assessed movement dysfunctions included delays or asymmetry in head control and trunk control.

While the experimental group received trunk activation treatment from NDT-certified pediatric therapists (OT, PT, and SLP), the control group received parent-infant-play as facilitated by licensed Child Life Specialists. By the end of the eight-week intervention, only five infants in each group had completed enough interventions to be included in the study. Researchers were able to conclude that infants receiving the trunk activation protocol significantly improved movement patterns when compared to the control group. This indicated the importance of administering a postural-specific treatment through certified therapists.

Additional studies have focused on functional movements beyond head and trunk control. Yonetsu et al. (2014) studied the effects of a single NDT session as it pertained to improving sit-to-stand movements in preschool-aged children with spastic diplegia. As compared to typically developing children in the control group, researchers concluded that the basic movements (forward trunk tilt hip flexion and dorsiflexion) required for sit-to-stand transfers significantly improved after one NDT session.

Twenty-eight subjects with diplegic cerebral palsy (between the ages of two and six years) participated in an NDT intervention study performed for a little over three months. As compared to the control group who did not receive NDT, 15 participants significantly improved in rolling, siting, kneeling, and crawling. However, there was no significant improvement in walking, jumping, or running (Labaf et al, 2015). The explanation as to why no improvement had occurred in these areas was because the authors may not have presented activities to motivate the participants to perform walking, jumping, or running.

Kilinc et al. (2016) assessed NDT/Bobath-based trunk exercises on the effects on trunk control, upper extremity function, walking, and balance in participants post-stroke. Twenty-two patients (mean age 55 years old) were randomly assigned to two groups: the treatment group received the trunk exercises and the control group received conventional physiotherapy exercises.

Each trunk program was tailored to fit the needs of each patient—as assessed by the Trunk Impairment Scale (TIS), the 10-minute walking test, the stroke rehabilitation assessment of movement (STREAM), functional reach (FR), Berg balance test, and the timed up-and-go test (TUG). Results revealed that both groups showed improvement in motor function, but the treatment group gained significant improvement. This meant that a well-developed Bobath-based program could improve walking, balance, trunk control, and arm function in post-stroke patients.

A few studies applied NDT in order to examine results regarding gross motor function, fine motor function, and muscle tone. In a study conducted by Lee et al. (2017), 42 children with cerebral palsy participated in an intensive NDT program that was held daily for 60-minutes, three times a week for six months. The purpose of this study was to compare the intensive NDT program with conventional NDT programs, as were applied to developmentally delayed children with (and without) cerebral palsy. Both groups showed improvements in gross motor/fine motor function and were able to retain improvements after three months of conventional NDT.

Mikołajewska (2012) assessed 60 patients, all at least six weeks post-ischemic stroke: 30 subjects with left-side hemiparesis and 30 with right-side hemiparesis. The NDT/Bobath-based rehabilitation approach took place over 10 sessions in a two-week period. Researchers noted that the participants who had received NDT made significant improvements in muscle tone according to the Ashworth Scale, as compared to the control group (16 cases out of 25). Given that 35 of the participants came in with normal muscle tone, spasticity couldn't be accounted for in the study.

NDT combined and compared to other therapeutic interventions

As many skilled therapists know, a combination of interventions may provide greater benefits to our patients instead of intensely applying one single approach. The literature reveals studies that combine NDT-based therapy programs with other relevant rehabilitative approaches. Other research groups have sought to compare NDT's effectiveness with other approaches.

Soo Ji Kim et al. (2012) conducted a study combining NDT with rhythmic auditory stimulation for 28 patients with cerebral palsy. Each patient had bilateral spasticity, which impeded their ability to effectively ambulate. Results revealed that rhythmic auditory stimulation significantly improved the participants' gait patterns in the following areas: cadence, walking velocity, step length, and stride length. However, results also revealed that NDT significantly improved internal and external rotation of the hips.

Another group in Iran conducted a similar study comparing sensory integration and NDT when applied to participants with cerebral palsy (Shamsoddini et al, 2010). Twenty-two children between age two and six years with spastic CP were randomized into the two treatment groups. After three months' worth of intervention, both treatment groups showed significant improvement in rolling, sitting, crawling, and kneeling. Neither group revealed significant improvement in walking, jumping, or running.

Researchers thought that sensory integration, since it could be used to elicit motor function, could be a reason for both groups' significant improvements. Absence of improvement in walking, running, or jumping may have been because the intervention was only for three months, as well as that researchers didn't really present activities that would motivate those actions.

In summary, both NDT and SI treatments have the ability to promote and restore functional movement patterns for children with CP; however, both approaches employ different paths to get there. SI focuses on sensory abnormalities that impede motor function and commonly address those abnormalities with play activities.

Wuang et al. (2009) examined the effectiveness of NDT, sensory integration (SI), and the perceptual-motor therapies as were randomly assigned to 120 children. An additional 40 children (representing the control group) did not receive any of the interventions. Participants were required to have a qualifying diagnosis of mild mental retardation (as determined by the Wechsler Intelligence Scale for Children) and deficits in two or more skills including social participation, self-care tasks, health and safety, academics, and communication.

Note: What made this study unique was that researchers specifically excluded children with cerebral palsy and other neurological disorders from this study. Out of all of the interventions applied, SI was the cause for significant improvement; NDT demonstrated the lowest effectiveness against the control group. Arguably, NDT may not have been the most realistic approach with these participants, given that none of them had neurologically related movement problems.

A research group based in the Netherlands decided to compare NDT-based treatment (traditional infant physical therapy or "TIP") for infants within the COPCA program (Coping with and Caring for Infants with Special Needs).

Forty-six infants admitted to a NICU with abnormal general movements participated in this study. Results revealed that COPCA provided more caregiver or parent education and allowed infants more time to produce typical movements by themselves; TIP, on the other hand, focused mostly on facilitating movement and physical handling (Dirks et al., 2011). Although NDT-based treatments presently do not exclude family and caregiver involvement, there are therapists using NDT who can take away concepts from the COPCA program in order to improve their own practice, as well as to carryover treatment in a 24-hour management style.

Acar et al. (2016) compared the effectiveness of NDT-based treatment, as compared to using a Nintendo Wii game to improve hand motor function. Thirty participants with hemiplegic CP were randomly assigned to the two treatment groups, and received the exact same amount of treatment time (45-minute sessions, twice a week for six weeks). As identified by the Jebsen Taylor Hand Function Tests, both groups made significant improvement, but the NDT group took the lead. Researchers concluded that NDT could be an effective treatment to improve hand function in CP; however, combining Wii

Nintendo with NDT sessions could provide an increased motivation for hand-motor movement production.

Yatar et al. (2015) also used the Nintendo Wii approach in a randomized controlled trial study to compare and contrast the application of NDT to post-stroke patients. Researchers were focused on improving balance and participation in activities of daily living (ADLs). In the end, both treatments were effective in improving balance and ADL participation, with no significant difference or preference between the two.

Jung et al. (2017) compared application of NDT and Vojta therapy to two separate treatment groups. Vojta therapy is based on the reflexive locomotion used to elicit fundamental movements that make up typical motor function (see https://www.vojta.com/en/the-vojta-principle/vojta-therapy/fundamentals for further details). Thirty-seven infants, ages six to eight weeks, were randomly assigned to each treatment group with intervention focusing on limited head rotation and spinal convexities that caused asymmetrical posture. Results revealed that both treatments provided significant improvement, but that the score differences gave Vojta therapy the lead.

Liu et al. (2014) measured brain activation via Functional-MRI in post-stroke patients after applying mental practice and NDT-based physical exercise. Participants qualified if they had experience a first-time subcortical stroke and had exhibited deficits in right-hand movement. Mental practice is an intervention in which a participant imagines themselves performing a certain task.

Results revealed that a combination of NDT-based physical exercise and mental practice over four weeks significantly improved hand function, as compared to the group who received mental practice alone. Additionally, significant recovery was made with the combination of the two approaches, when compared to physical exercise alone.

Kim et al. (2015) examined the effectiveness of NDT, as well as NDT combined with the Adeli suit treatment for 20 children with spastic CP. The Adeli suit was designed for muscle tone management in a weightless environment: it is comprised of a full body uniform and auxiliary equipment attached via bungee cord. Therapists then set up the attached cords in order for the user's body to mimic typical extensor and flexor patterns of muscle groups to mimic functional movement of the body. Results revealed that both groups (NDT and NDT combined with the Adeli suit) significantly improved in gross motor/fine motor function. However, the combined treatment group showed significant improvement in more variables of walking than solely NDT (i.e. walking cadence, speed, and stride length).

What we can take away from the literature is that the efficacy of applied NDT to patients with neurological conditions is there, and that professionals are needed in order to continue to justify its application. We also know that NDT provides therapeutic benefits that very few other approaches can. On the other hand, other therapeutic approaches may fill some gaps within NDT in order to provide patients with holistic treatments.

Are there other NDT-appropriate neurological disorders?

The Bobath/NDT literature places a heavy emphasis on using this approach with persons with cerebral palsy and hemiplegia, likely due to NDT's origins from these two conditions. Since NDT promotes neuroplasticity and the reshaping of the central nervous system, what are the more recent implications about using NDT for other CNS disorders or diseases? Furthermore, let's consider the following questions before diving into the peer-reviewed literature:

1. If NDT is effective for cerebral palsy and hemiplegia, can it also be affective for similar CNS damage such as traumatic or acquired-brain injuries?
2. Can NDT be effective for infections of the central nervous system?
3. NDT seems to be a successful approach for neurological conditions with expected recovery. Can NDT be useful for fatal neurological conditions?

For the sake of time, only one research article per neurological condition has been selected.

Traumatic brain injury (TBI)

A traumatic brain injury (TBI) occurs when an external force causes damage to the brain tissue by means of a violent blow, a jolt, or a penetration to the head. Depending on the severity and the location of an injury, a TBI can result in motor, sensory, psychological, emotional, behavioral, and cognitive complications (Mayo Clinic, 2018). TBI results can range from mild concussive conditions to complete vegetative states. TBIs are not to be confused with acquired brain injuries (ABI), which is umbrella term describing CNS damage by external trauma after birth, as well as through other forces including stroke, tumors, anoxic brain injuries, degenerative conditions (multiple sclerosis, ALS, Alzheimer's), and toxin exposure (Brain Injury Association of America, 2018).

Sartor-Glittenberg and Brickner (2014) applied a multi-dimensional physical therapy program to three individuals with cerebellar ataxia, secondary to traumatic brain injury. Along with the other approaches used, NDT was included. The participants were 20 to 22 years of age, ranging from five months to six years post-injury. After the intervention, participants made functional gains in balance, coordination, endurance, and mobility. Although this study doesn't necessarily specify the effects of NDT on patients with stroke, it does point out the importance of using a multi-disciplinary approach in neurological rehabilitation.

Spinal cord injury (SCI)

An SCI occurs when any portion of the spinal cord sustains damage, thus causing motor and sensory loss below the sight of injury. Movement abilities after an SCI depend on the site of the injury as well as the severity of the nerve damage. If the affected individual has a total loss of both sensation and movement below the injury site, then damage is called a "complete spinal cord injury." Persons who still have some amount of sensation or movement below the injury site have what is called an "incomplete spinal cord injury." By focusing on only the symptoms that affect functional movement, SCI often results in a loss of sensation, as well as two types of muscle tone (depending on the injury): spasticity or flaccidity (Mayo Clinic, 2018).

The current scholarly research is very limited concerning the Bobath/NDT approach and its effectiveness for persons with spinal cord injury. However, there are certain clinics, such as the Bobath Centre in the UK, which address patients with incomplete spinal cord injuries. Specialists offer assessments and tailor-made NDT programs in order to improve muscle strength, postural control, and balance.

Brain tumor

A tumor, or another non-cancerous/cancerous form in the brain, is considered an "acquired brain injury." Primary brain tumors form from cells in the central nervous system, the most common being gliomas and astrocytic tumors. Depending on the size of the tumors and where they are located in the brain, even benign tumors can be life-threatening. Symptoms of a present brain tumor can include balance problems, weakness on one side of the body, sensation problems in the limbs, and ambulation difficulties (Web MD, 2018).

Geler-Kulcu et al. (2009) evaluated the effectiveness of a stroke rehabilitation program with NDT-based approaches for both post-stroke patients and patients with brain tumors. Twenty-one patients with each disorder (with similar lesions of the brain) were included in the study. Both groups made significant improvements in motor function in a post-intervention assessment; few differences were indicated between the two. This study was able to conclude that NDT-based stroke rehabilitation can be an effective recovery method for patients with brain tumors.

Dementia

In the DSM-5, terms such as "dementia" and "Alzheimer's disease" are now referred to as "neurocognitive disorders" (although clinicians still refer to the older terms to avoid confusion). Dementia is an umbrella term that refers to a compilation of degenerative disorders that affect the brain. According to the National Institute of Neurological Disorders and Stroke (NINDS, 2018), dementia is defined as "the loss of cognitive functioning—the ability to think, remember, problem solve or reason—to such an extent that it interferes with a person's daily life and activities."

Dementia with lewy bodies occurs when an abnormal amount of alpha-synuclein protein is present in the brain. Lewy body dementia and Parkinson's disease dementia (which often has lewy bodies, as well) encompass the same cognitive, emotional, behavioral, and perceptual problems as Alzheimer's disease; however, both conditions may also include postural and movement limitations (Alzheimer's Association, 2018).

LeJeune and Kurfeust (2009) identified how NDT can benefit persons with dementia when it comes to self-feeding and swallowing as the disease progresses. From an OT perspective, biomechanical alignment, posture, and innate movement patterns for self-feeding can still be optimized in the later stages of dementia via NDT application. Perceptual and tremor-like deficits also make it difficult to self-feed effectively, as seen in lewy body dementia. Authors concluded that OT, using the NDT approach, can identify and facilitate typical posture for safe eating; this, combined with speech therapy, facilitates safe swallowing patterns.

Multiple sclerosis (MS)

MS is a complicated neurological and degenerative disorder that reveals itself in multiple subtypes. Generally, the immune system attacks the protein, or the "myelin sheath," around neuronal tissue in the brain and spinal cord. Eventually, nerve deterioration or damage can occur as well. Depending on where neuronal lesions occur, movement-related symptoms can include the following: numbness or weakness in one or more limbs, weakness of the trunk muscles, tremors, unsteady gait, and an overall lack of motor coordination (Mayo Clinic, 2018).

Since MS comes in multiple types with periods of relapses and remissions, it is essential for therapists to pinpoint the impact of the disease on movement before assigning an NDT-based program. Kubsik-Gidlewska et al. (2017) describe what is called the Kinesis program. Through a combination of NDT and PNF principles, this program gradually recovers loss of function. Therapists work with MS patients by addressing postural reflexes, promoting typical postural for functional tasks, and inhibiting atypical patterns, while maintaining a tailor-made program to fit the patient's functional needs.

Parkinson's disease (PD)

PD is also considered a neuro-degenerative disorder as it attacks dopamine-producing cells in neurons located in the substantia nigra (with the CNS). Motoric symptoms may include: tremor at rest, bradykinesia (slow movement), rigidity of the limbs, and gait and balance issues (Parkinson's Foundation, 2018).

Although current research is limited, many clinics around the world use NDT as a treatment approach to the movement deficits in Parkinson's disease.

The Manchester Neuro Centre treats patients with Parkinson's disease and other neurological conditions. The physiotherapists state that they actively use Bobath/NDT for patients with Parkinson's disease in order to reduce muscle and joint stiffness, to facilitate typical movement patterns, and to align the body for functional participation.

Tomlinson et al. (2012) reviewed various physiotherapy approaches and the effectiveness in treating Parkinson's disease, one of which was the Bobath/NDT approach. Overall, researchers concluded that physiotherapy interventions were effective, but only in providing short-term results for patients with Parkinson's disease. There were significant improvements in gait speed, functional reach, and balance—only for a brief time.

Amyotrophic lateral sclerosis (ALS)

ALS belongs in a category of motor neuron diseases in which there is a gradual deterioration (or death) of motor neurons in the central nervous system. Such damage dissolves the communication between the CNS and the body to voluntary coordinate movement. Once the communication is completely cut off, muscle tissue begins to fasciculate (twitch) and atrophy. ALS eventually leads to death because the muscles coordinating the respiratory system begin to fail (NINDS, 2018).

Pyszora et al. (2012) in Poland conducted a pilot study involving 10 patients (three men, seven women) with ALS. Four of the patients received NDT as part of their home health physiotherapy. According to questionnaire responses, none of the patients thought that they had made any functional improvement in ambulation and ADLs as a result of therapy. Lack of functional progress should come as no surprise, given the debilitating course of the disease. However, physiotherapy approaches (including NDT) improved sleep quality and reduced overall pain and breathing difficulties.

Infection-related encephalitis

Encephalopathy is considered any type of "diffuse disease to the brain that alters brain function or structure" (NINDS, 2018). Causes include bacteria/viral infections, toxin exposure, increased pressure inside the skull, brain tumors, lack of oxygen to brain tissue, and malnutrition. Common symptoms of encephalopathy include altered mental state, memory loss, progressive loss of consciousness, myoclonus (involuntary twitching of certain muscle groups), and muscle weakness/atrophy (NINDS,

2018). Depending on their severity, symptoms can improve with treatment or they can leave permanent—even fatal—damage.

Research is lacking when it comes to using NDT approaches on patients with functional deficits resulting from infection-related encephalopathy. Miller, Miller, and Goldberg (2006) examined and treated a 55-year-old-woman with West Nile virus paralysis. The patient developed encephalitis and aseptic meningitis, which then led to bilateral weakness of her lower extremities. Additionally, she experienced cognitive impairment and hallucinations. Researchers applied many physical therapy interventions, including NDT, which attempted to address her loss of functional movement in the lower extremities. Over the course of 21 weeks, the patient regained function and was able to ambulate without medical equipment assistance.

Billing for NDT

NDT is under the following Current Procedural Terminology:

"CPT® 97112: Neuromuscular reeducation of movement, balance, coordination, kinesthetic sense, posture, and proprioception. Examples include, Proprioceptive Neuromuscular Facilitation (PNF), Feldenkrais, Bobath, BAP'S Boards, and desensitization techniques."

Since "Bobath" falls within this code, it is included in the 97000 CPT-4 series called "Physical Medicine and Rehabilitation," all of which are usually available to licensed physical and occupational therapists in a wide variety of clinical settings (APTA.org, 2018; AOTA.org, 2018). As with other CPT codes, CPT 97112 is considered a "timed" code in which therapists can bill several units for time spent (typically 15 minutes per unit).

CPT 97112 is considered a "therapeutic procedure" code that can only be documented appropriately if treatment is administered by direct, one-on-one contact with a patient. Its use could be reasonable and necessary for documented impairments that affect the neuromuscular system including:

> "Loss of deep tendon reflexes and vibration sense accompanied by paresthesia, burning, or diffuse pain of the feet, lower legs, and or/fingers, nerve palsy, peroneal nerve injury causing drop foot, muscular weakness or flaccidity as a result of cerebral dysfunction, spinal cord disease or trauma, poor static or dynamic sitting/standing balance, loss of gross and fine motor coordination, and hypo/hypertonicity" (American Medical Association, 1999).

As with the use of any other CPT code, it is essential for therapists to justify its use via evaluation and documentation. Therapists must obtain objective measurements indicating loss of motion, strength, balance, coordination, mobility, joint range, or whatever relevant area that impacts function. The following handful of assessments might be appropriate:

- Berg Balance Test.
- TUG-Timed Up and Go Test.
- AIMS- Alberta Infant Motor Scale.
- Functional Reach Test.
- Tinetti.
- Functional Gait Assessment.
- Romberg's Test.
- Manual Muscle Testing.

- Bruininks Motor Ability Test.
- Test of Gross Motor Development.

Objective measures will provide quantitative information that insurance providers like to see; however, therapists need to documentation the connection between the test results and documented neurological impairments (i.e. stroke, cerebral palsy, etc.) and how these impairments impact function (e.g. activities of daily living, mobility, and ambulation).

Once treatment sessions have started, document:

1. Specific Bobath/NDT-related exercises conducted by the patient;
2. Connect the exercise with functional purpose;
3. The patient's response to treatment;
4. The patient's progress as compared to prior treatment sessions;
5. The instruction and assistance provided by the therapist;
6. Make the note reflect why a skilled therapist was needed to provide this specific treatment (AMA, 1999).

The following treatment note encompasses the above examples:

A patient completed 15-minute therapeutic exercises utilizing a therapy ball to achieve dynamic sitting tasks. These exercises were carried out for the purpose of restoring unsupported sitting balance with the goal of completing lower body dressing tasks; the patient required five tactile cues to maintain unsupported sitting balance and required two rest breaks (as compared to five rest breaks last session), due to unilateral trunk weakness secondary to post-CVA hemiplegia. Patient's O2 saturation was above 90% at rest; with activity on 2L supplement, the patient reported pain 0/10.

Advocating for NDT

As of 2017, both the APTA (American Physical Therapy Association) and the AOTA (American Occupational Therapy Association) were heavily involved in some legislative changes concerning the Medicare 2018 physician fee schedule. According to CMS (Centers for Medicare and Medicaid Services), certain CPT codes have been "misvalued," meaning that Medicare claims that they have been paying out too much money to providers.

Both therapy associations worked closely with the American Medical Association (AMA) to increase the values of six CPT codes, including code 97112. This is just one of the many examples of advocating for NDT and making sure third parties acknowledge the benefits it provides for patients through the hands of physical and occupational therapists.

Every year, like many healthcare providers, rehabilitative care comes under heavy scrutiny because it is an expensive business; payers will take legislative steps to save money where they can. This means that the details of the treatments that physical and occupational therapists administer are frequently monitored and questioned—rightfully so, since insurance companies want to ensure that they are getting their money's worth. When it comes to defending NDT as a legitimate intervention, therapists need to participate in some or all of the following:

1. Use of supportive and accurate documentation: Back your clinical practice with optimal documentation. This includes staying up to date on therapy lingo and acceptable

abbreviations/acronyms, appropriate treatment codes for your particular practice setting, well-researched standardized assessments and additional objective/subjective evaluation tools, and ethical considerations. To fully support NDT as a legitimate treatment option, payers need to have recorded proof of use, the patient's response to treatment, the progress the patient is making, and why a skilled therapist is needed to provide NDT.

2. Certification and continuing education courses: If you plan on actively using NDT in your clinical practice in an effective matter, then it is essential to seek out continuing education courses to keep your skill sets up-to-date. As mentioned previously, NDT is an evolving process; sometimes techniques and applications change for the benefit of patients. If you are seriously considering specializing in NDT, seek out available certification courses at http://www.ndta.org/certificate_courses.php.

3. Research Involvement: Full-time working therapists already have a lot on their plate concerning the typical obligations of clinical work. For those who can find the time, consider participating in research projects that aim to further support the use of NDT. Insurance companies are constantly looking for empirical research (or lack thereof) to support or challenge the use of therapy treatments. As mentioned earlier, "new" research is lacking for the efficacy of NDT and other neurological conditions outside of cerebral palsy and hemiplegia.

4. Legislative work: Get involved in your local legislative groups. Stay on top of recent or proposed healthcare changes that can impact how you will be able to practice in the future.

Conclusion

For years, the Bobath/neuro-developmental treatment approach has firmly developed its roots in clinical practice for physical and occupational therapists worldwide. Continuing research efforts seek to re-affirm its efficacy for treating cerebral palsy, hemiplegia, and a wide variety of acquired or traumatic assaults to the central nervous system (CNS). NDT is frequently used as a means to improve functional movement as it pertains to ambulation, transfers and mobility, as well as ADL performance. Although much of the research is solid, it is essential that clinicians continue to contribute their findings to available NDT materials. Doing so allows the NDT approach to evolve as we learn more about both the CNS, as well as about the ability of individuals to recover movement.

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QUIZ

1. Before the Bobath/NDT approach, clinicians were ineffectively using therapeutic exercises and muscle re-education to treat individuals with cerebral palsy and hemiplegia with similar methods to:
   a. Patients with dementia.
   b. Polio survivors.
   c. Patients with multiple sclerosis.
   d. Typhoid fever survivors.

2. Which of these is NOT a basic principle of the Bobath concept?
   a. Muscle weakness or tightness in hemiplegia and cerebral palsy is a direct result of lesions or damage to the central nervous system (CNS).
   b. Individuals with cerebral palsy and hemiplegia have a disorder of posture AND movement.
   c. Atypical movement as a result of peripheral nerve damage has the potential to recover.
   d. Atypical movement as a result of damage to the CNS has the potential to recover.

3. Which is TRUE about spasticity?
   a. Spasticity is the same as rigidity.
   b. Spasticity is the same as hypertonicity.
   c. Spasticity is a subtype of hypertonicity.
   d. Spasticity is a subtype of rigidity.

4. "The central nervous system has the ability to shape and/or renew itself in response to practiced activities," defines what theory supported by NDT?
   a. Brunnstrom.
   b. Neuroplasticity.
   c. Bobath Concept.
   d. Motor Learning Theory.

5. According to peer-reviewed research, which of the following is true about NDT in regard to other treatment strategies:
   a. NDT is more beneficial to a patient as a stand-alone intervention.
   b. NDT may be more beneficial for a patient when combined with other effective treatment strategies.
   c. NDT is better than other treatment strategies currently being used to restore functional movement.
   d. NDT is not effective for functional recovery of movement.

6. A brain tumor:
   a. Is a non-cancerous form that won't cause central nervous system damage.
   b. Is not life-threatening if it benign.
   c. If in a non-cancerous form can still cause balance problems, weakness on one side of the body, sensation problems in the limbs, and ambulation difficulties.

d. Is considered a traumatic brain injury.

7. CPT 97112 is a therapeutic procedure code which can be used if:
   a. Administered as direct, one-on-one contact with a patient with documented impairments that affect the neuromuscular system.
   b. Applying a hot pack modality to enhance movement of a particular muscle group.
   c. Applying a tens unit to a paralyzed extremity.
   d. Evaluations do not indicate movement impairments that affect the neuromuscular system.

8. What are the four ways mentioned in this course that therapists can advocate for NDT?
   a. Use of supportive and accurate documentation, certification and continuing education courses, research involvement, and legislative work.
   b. Use of supportive and accurate documentation, research involvement, legislative work, and advertisement.
   c. Research involvement, legislative work, advertisement, and providing NDT to more patients on caseload.
   d. Research involvement, legislative work, certification and education courses, and providing NDT to more patients on caseload.

9. Non-spastic cerebral palsy:
   a. Makes up 80% of cases of cerebral palsy.
   b. Does not affect the trunk muscles.
   c. Is also called “pyramidal.”
   d. Includes ataxic and dyskinetic subtypes.

10. Physical handling:
    a. Is unique to NDT.
    b. Provides manual cues to access missing components of movement.
    c. Is synonymous to totally assisting someone with a movement.
    d. Fulfills movements for the person so they don’t have to complete it on their own.