Doggon' Easy in the Big Easy: Managing the Canine Neuro-Rehabilitation Patient through the Adaptation of PNF and NDT Theory

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Description

The application of NDT and PNF theory, principles, and techniques as adapted in the management of the canine neuro-rehabilitation patient will be presented through case examples. With a foundation in canine and human neuro-anatomy, neuro-physiology, functional analysis, and neurological physical therapy, the presenters will detail the management of the canine rehabilitation patient, focusing on motor control and the identification and remediation of abnormal postures and movement patterns. The application of manual treatment and facilitation techniques derived from NDT and PNF theory in conjunction with the use of external therapy aids and assistive devices will be highlighted with a focus on facilitation of and improvement in the quality of movement and quality of life of the canine patient.

Learning Objectives

-The participant will identify normal and abnormal posture and movement patterns as identified in the canine neuro-rehabilitation functional evaluation.
-The participant will describe two NDT and PNF techniques to be appropriately, safely, and effectively applied in the treatment of the canine neuro-rehabilitation patient.
-The participant will explain the use of two external adjunctive therapy aids and assistive devices and their appropriate and safe application for the canine neuro-rehabilitation patient with regards to NDT and PNF theory.

NDT Theoretical Basis for Treatment

"Neurodevelopmental treatment (NDT) is a problem-solving approach to the examination and treatment of the impairments and functional limitations of individuals with neuropathology." NDT focuses on the evaluation and treatment of sensorimotor impairments and functional limitations that therapists can impact. NDT is a living concept that incorporates classic NDT philosophies with current scientific findings, and principles of neuroplasticity, motor control, motor development, and motor learning.

NDT originated in the 1940s with the work of Karel and Berta Bobath in the treatment of individuals with neurological disorders of posture and movement. The Bobaths viewed that their work would change across time based on the populations served (animals!), new experiences, and clinical research. Hence, the practice of NDT, as well as some of the theory and practice have changed through the years. At the time that the Bobaths were practicing, it was expected that individuals with a neurologic injury could only hope to compensate for their functional limitations or undergo orthopedic surgeries for the resultant contracture and deformities. The Bobaths' work introduced a concept of functional recovery versus compensation.

Neuroplasticity

"Plasticity is the ability of the central nervous system (CNS) to reorganize its structure, connections, and function and its response to intrinsic or extrinsic stimuli throughout life." NDT is a functional neuro-recovery model versus the previous compensatory models employed during the Bobaths' time. *Developmental plasticity* deals with recovering from injuries that occur in the developing brain. *Adaptive plasticity* looks at how the CNS optimizes existing function and compensates for lost function following CNS injuries. Animal and human studies show that neural plasticity is possible in the infant and adult brain. Therapists study the concepts of neural plasticity and related findings to decide how to provide meaningful and functional recovery. Factors to consider are the age of the patient, the variation of the injury, the time lapsed since the injury, aerobic exercise, function-specific exercise, practice, and motivation.

Typical and Atypical Postures and Movement

When treating the human or canine patient, therapists observe what may be typical or atypical about postures and movements and these observations guide therapists in how to direct interventions. Understanding typical developmental postures, transitions, and movements, is of paramount importance. This understanding allows the therapist to identify where postures, transitions, and movements are atypical. Identification of not only the presence of atypical postures, transitions, and movements, but also why they are occurring, either through the presence of one or more impairments, or the absence of one or more functional strengths, allows the therapist to best direct the therapeutic intervention in an effective manner.

Typical and atypical postures and their resulting compensations are well documented in the human patient with neurologic injury, less so in the canine patient. Today, in the canine patient, description of typical and atypical postures, transitions, and movements have been made through observation and experience with this subset of the population and through extrapolation from the human population where appropriate. Further study is warranted in these areas in the canine population to ensure the accuracy of observation and efficacy of resultant therapeutic interventions derived from these observations. Identification of these atypical postures, transitions, and movements is also important as it provides a roadmap for treatment based on the likelihood of primary or secondary impairments arising from said atypical postures, transitions, and movements. Prognostication of potential impairments allows the therapist to possibly prevent compensations from occurring and also allows therapists to build in the components of typical postures, transitions, and movements that are missing from the canine patient's movement repertoire.

Oftentimes, the development of the above referenced impairments is in response to disturbances within the posture and movement system, or deviations from how the posture and movement system is typically used. Posture and movement are two subsystems of motor control that are blended to attain collaboration for functional activities. The specific goals of the subsystems are alternate in their aims, but complementary when their interactions occur in intended activity. Postural control requires the ability to right the trunk, head, and limbs and to maintain and regain balance utilizing feedback and feedforward mechanisms.

There is an anatomical basis for the posture and movement model. The particular characteristics of skeletal muscles establishes them as being more suited for either postural activity or movement. Again, an understanding of typical and atypical postures, transitions, and movements will allow the therapist to identify when the patient is engaging the muscles appropriately, or when the patient is attempting to compensate for a particular impairment (i.e. compensating for weakness of the cervical postural muscles by engaging muscles more suited for cervical movement in a particular postural task). Identification by the therapist of these compensations will allow for appropriate intervention.

PNF Philosophy of Treatment

Proprioceptive neuromuscular facilitation (PNF) is a method of manual treatment traditionally utilized by PTs for treatment of patients with neuromuscular and musculoskeletal disorders. PNF is more than just passive, functional, diagonal patterns of movement, but utilizes a philosophy and specific principles which are essential for promotion of normal patterns of, and improved quality of, movement.

The PNF philosophy, first described by Maggie Knott, a PT at the Kaiser Foundation Rehabilitation Center, Vallejo, California, in 1948, includes a focus on a positive approach to treatment. All of the body movements, both of the PT and of the patient, incorporated into the PNF patterns, have a specific, purposeful, and functional goal. PNF uses the stronger components of this functional movement or of the extremities to strengthen the weaker through irradiation and overflow.

PNF principles and techniques are based on the neurophysiologic principles suggested by Sir Charles Sherrington in 1947. These include: afterdischarge, temporal summation, spatial summation, irradiation, successive induction, and reciprocal innervation/inhibition. *Overflow, or afterdischarge,* describes the theory that the effect of a stimulus continues after the stimulus stops. The strength and duration of the afterdischarge is directly related to the strength and duration of the stimulus. *Temporal summation* describes the theory in which a series of weak stimuli within a period of time will combine to cause excitation. *Spatial summation* describes the summation/reinforcement of weak stimuli which are applied simultaneously to different areas of the body and, together, cause excitation. *Irradiation* is a spreading and increased strength of a response, which might be excitatory or inhibitory. *Successive induction* is an increased excitation of the agonist following stimulation of the antagonist. *Reciprocal innervation/inhibition* occurs when contraction of the agonist occurs simultaneously with inhibition of the antagonist, resulting in coordinated movement.

A goal of PNF treatment is to tap the maximal response to effectively increase motor and sensory awareness. Repetition of this maximal response promotes motor learning. Additionally, PNF is an intensive program with continuous activity. "Active rest" is an integral part of PNF treatment. In summary, the goal of PNF treatment is resultant optimal function with an integrated neuromuscular system.

The principles/procedures utilized during PNF treatment include consideration of: patient position, PT position and body mechanics, the desired pattern of movement, manual contacts, the use of wind-up, elongation, or stretch, verbal cues, visual cues, appropriate resistance, approximation or traction, normal timing, desired contraction type, and irradiation. These principles might form a "checklist" of sorts that a PT might utilize to evaluate his or her treatment and to improve upon the effectiveness of the treatment.

Physical Therapy Evaluation, Assessment, and Treatment Planning

The neuro-rehabilitation evaluation is a marriage of the neurology and physical therapy evaluations and is not free-standing, usually incorporating treatment as well. Effort should be made to include hands-off, observational evaluation along with hands-on, manually-assisted/facilitated techniques. Essential components of the neuro-rehabilitation evaluation are:

- The *subjective evaluation* should include review of past medical history, the client's chief complaint and goals, the patient's social history and home environment, as well as discussion of other interventions and their perceived effectiveness.
- The *physical examination* should include documentation of baseline vital signs and at least a review of systems.
- *Reflexes and reactions*, including spinal reflexes, conscious proprioception, dancing/wheelbarrowing, hemi-walking, and hopping reactions, should be evaluated. These tests may be interpreted by their presence or absence as well as the quality of the patient's

response. In the "down" patient, observation of muscle tone responses to changes in position may also be helpful.
- A *cranial nerve examination*.
- A *dermatomal sensory examination*.
- Finally, the *functional mobility evaluation*, including evaluation of "motor control" in the patient's varied postures (ie. standing, sitting, lying, ADL postures), transitions, functional mobility, and gait, should be performed. Attention should be paid to the presence and quality of motor control, including consideration of balance, coordination, strength, and sensation, and their contributions to muscle tone and independent functional mobility.

Standardized, objective outcomes documentation is imperative in the Evidence Based Medicine (EBM) world in which we practice, though tools which assess functional mobility and, especially, quality of movement in the neuro-rehabilitation patient are rare. This author has utilized kinematic motion analysis and adapted functional movement scales (eg. C-FIM, C-TUG) for use in small animal neuro-rehabilitation, though these measures continue to be under development and have not yet been assessed with regards to reliability or validity. These tools are helpful at the initial assessment and periodically through the rehabilitation journey.

Neuro-rehabilitation Treatment Planning

In treatment planning, the neuro-rehabilitation PT must consider not only the period of time that has elapsed since the neurological insult, but also any precautions or contraindications based on the patient's diagnosis and/or comorbidities, the level of functioning of the patient, and the location or environment in which the therapy is performed.

Through a PNF/motor control treatment focus, the PT will progress the patient in functional recovery and (1) promote/elicit early reflexive movement and encourage the patient to acknowledge that movement; (2) promote active, independent, and functional movement; and, (3) normalize muscle tone for improved quality of movement. We must remember that each patient is an individual and may begin his recovery at a different stage. As PTs, we must assure that our neuro-rehabilitation strategy is appropriate, efficient, and pertinent to our patient/client's functional goals.

PNF Procedures and Techniques for Eliciting Early Reflexive Movement

Early in neurological recovery, the patient might be hypotonic, with flaccid muscle tone, only responding reflexively with or without acknowledgment of the movement or muscle contraction. The patient might have absent deep pain or cutaneous sensation. Polysynaptic reflexes might be present. In this stage, the PT focuses treatment on attempts to elicit and promote early reflexive movement as well as patient acknowledgement of that movement.

Treatment options/tactics at this stage might include: 1. reflexes for withdrawal, crossed extensor, extensor thrust, and protective extension, and 2. PNF procedures of stretch, elongation/windup, irradiation, approximation, and traction.

Withdrawal reflexes (WR) applied with a toe pinch, tickle, or other annoying or noxious stimulation to the digits, web space, and/or pads may result in a flexion response on the ipsilateral limb and crossed extension on the contralateral limb. WR should be attempted in varied positions and with the targeted muscles elongated, "wound up," or, at least, on a stretch. Attempts should be made to strengthen the distal components of the WR. A more functional/meaningful patient position (supported standing or otherwise weight bearing) will promote motor learning, especially with augmented sensory input (eg. weight bearing with approximation). The use of temporal summation in the most involved (most flaccid) cases MAY result in a response-- patience is a virtue!

The PNF procedures of stretch, elongation/windup, irradiation, approximation, and traction can be utilized similar to the WR in varied positions and environments.

Any or all of these tactics might be utilized in a simple, but effective home program. Home program options during this phase include: 1. sensory stimulation, even through stimulation of the hair/fur follicles (ie. petting, scratching, brushing), 2. toe, pad, or web space pinches and tickles, in in varied body positions (eg. lateral recumbency, supported standing), and 3. "tail work" with sensory stimulation, approximation, and traction. In this stage, it is the author's experience that the client is usually tentative and anxious about physically contacting his pet. In general, sensory stimulation, can be of great benefit to the patient in the early stages of recovery and should be encouraged.

PNF Procedures and Techniques for Initiation and Integration of Active Movement

As the patient progresses through his neurological recovery, he may present with trace to fair grade (1/5-2/5) muscle contractions, especially proximally. One limb might be more functional than another. Muscle tone may fluctuate based on body position and patient level of arousal. The patient might be able to maintain a position independently but has poor balance and requires assistance to transition. The client might complain that the patient "doesn't like" toe pinches any longer as his sensation is returning. Additionally, he might be more focused with grooming, licking, or chewing at the involved limb/paw (possibly due to paresthesias). In this stage, the PT focuses treatment on promoting independent initiation and acknowledgement of active movement by the patient.

Treatment options/tactics at this stage might include: 1. PNF techniques of massed flexion and rhythmic stabilization, and 2. PNF procedures of irradiation, appropriate resistance, approximation, and traction.

Massed flexion (MF) is a technique used to improve trunk muscle activation, enhance motor control of "shortening" and "lengthening" of the trunk, improve coordinated contractions between fore limb and hind limb muscle groups, and improve independence and quality of movement during "bed mobility" activities, such as rolling from lateral to sternal recumbency or lateral recumbency to sitting.

Additionally, in the neurologically-involved patient, MF promotes a "link" from the pectoral girdle to the pelvic girdle. The patient may initiate all active movement for functional mobility with muscle groups cranial to the level of the lesion. Utilizing active (or appropriately resisted) motion in the pectoral limb results in irradiation through the trunk and reflexive motion in the pelvic limb. Through this technique, MF can help to strengthen the response of weaker muscle groups.

For MF, the patient begins in a lateral recumbent position as the PT reaches the patient's fore limb into shoulder and elbow extension and hind limb into hip and stifle extension, elongating the (up side) lateral trunk (and shortening the down side). Successful treatment requires a coordinated effort by the PT and patient and, therefore, application of appropriate resistance (or assistance, if necessary) must be coordinated with a stimulus for active effort by the patient. The PT might choose to resist distally, at the fore limb and hind limb paws or proximally, at the scapula and pelvis. This choice is based on the patient's functional abilities and the goal of treatment, keeping in mind basic biomechanical principles. The patient is encouraged to look towards his hip, laterally flexing his cervical spine and activating the lateral flexors of his trunk, meanwhile retracting the scapula, flexing the shoulder (and possibly flexing the elbow), bringing the pelvis into a relative cranial ventral position, and hip into flexion (and possibly stifle flexion). Depending upon the goal of treatment, the end of the exercise might be successful transition to sternal recumbency or to sitting. This activity can also be performed in sitting or standing.

Rhythmic stabilization (RS) is used to increase active and/or passive range of motion, strength, stability, and balance, and to decrease pain. It is a technique in which the patient responds with alternating isometric contractions when external, manual resistance is applied. There is no motion intended by the patient, in fact, the patient will intend to maintain his position against this manual, external resistance.

RS is a technique that can be applied in varied patient postures and positions on a variety of surfaces. The PT is reminded to use a comfortable manual contact and to maintain contact with the patient throughout application of the technique. Attention to the amount of resistance applied and position of application (specifically, the length of the lever arm) is necessary for safe application of this technique.

Use of the PNF procedures of irradiation, appropriate resistance, approximation, or traction during traditional therapeutic exercises and activities will enhance the response of the patient to therapy. Through use of these procedures, we are reminded of the PNF philosophy, using the strengths of one to strengthen a weaker body part. When applying resistance, it is important to note the patient's response to more or less resistance. Too much resistance might result in undesired movement patterns or abnormal synergies, while too little resistance might not cause a perceptible response. A general rule is that "less is more."

Home program options during this phase include: 1. cookie stretches in sitting or standing, 2. transitions from lateral recumbency to sternal or sitting or standing, 3. supported standing, and 4. assisted or supported walking (in supported standing/weight bearing or in non-weight bearing, to encourage reflexive stepping).

PNF Procedures and Techniques for Improved Quality of Movement

In this phase, the patient may demonstrate significant compensatory movement strategies, due to the presence of muscle imbalance and abnormal muscle tone. Some muscle groups may be hypertonic or spastic (misinterpreted as "strong") compensating for those that are hypotonic (or "weak"). The deep pain negative patient may spinal walk. Cutaneous sensation is altered. Polysynaptic reflexes are present but are inhibited by active/subconscious muscle contractions. The PT's goal in this stage is to normalize muscle tone.

Treatment options/tactics at this stage might include: 1. postural reflexes, and 2. Rood Sensorimotor Technique.

The animal with a normally integrated nervous system can suppress postural reflexes, however, the muscle tone of the patient with neurological impairments will be influenced by these postural reflexes and changes in position relative to gravity and head/neck position. The following is a brief review of some of the most "helpful" postural reflexes and their influence on the muscle tone of the animal.

- *Symmetric tonic neck reflex (STNR)*, also known as "the cat under the fence reflex". Cervical spine extension promotes pectoral limb extension and pelvic limb flexion while cervical spine flexion promotes pectoral limb flexion and pelvic limb extension.

- *Asymmetric tonic neck reflex (ATNR)*, also known as the "bow and arrow reflex". Cervical rotation will result in ipsilateral limb extension and contralateral limb flexion.

- *Symmetric tonic labyrinthine reflex (STLR)* promotes limb flexion when the body is in a prone or sternal recumbent position while limb extension is promoted with a supine or dorsally recumbent position.

Through observation of muscle tone fluctuations with body position changes, the PT can use varied postures during treatment to influence tone and facilitate activity in specific muscle groups, thereby making traditional therapeutic activities more efficient.

Margaret Rood, a physical and occupational PT, in 1966, developed an approach to neuro-rehabilitation focusing on motor development and sensory stimulation techniques, which we now call *Rood Sensorimotor Technique (RST)*. Therapeutic activities progressed from mobility exercises to stability exercises and, finally, to controlled mobility (or mobility superimposed on stability, in which the distal component is fixed and movement occurs more proximally). Finally, Rood's therapeutic activity progression included a focus on achieving skill or coordinated movement, which enables the distal segment to manipulate an object (or the environment) while maintaining a stable posture. Rood's sequence of activities resembled that of normal human motor development, moving the center of gravity of the body further away from the base of support, thus challenging the stability of the body against the resistance of gravity.

Interestingly, RST also incorporated the use of sensory stimuli to promote stability or mobility and to modify the resting muscle tone of the patient. For stabilizing contractions, joint approximation and compression techniques were utilized, while mobilizing contractions were promoted with the quick stretch technique. Muscle tone was increased (or muscle contractions facilitated) with the application of sensory stimuli such as approximation, the quick application of ice (10-30 seconds), compression, light touch, quick stretch techniques, resistance (manual or mechanical), muscle belly tapping, or traction. Muscle tone was decreased (or muscle contractions inhibited) with prolonged stretching, deep pressure, warm or neutral temperature, prolonged icing (15-20 minutes), and slow stroking. The effects of the application of these sensory stimuli were explained by reflexive activation of muscle spindles, Golgi tendon organs, and cutaneous receptors.

Home program options during this phase include: 1. "targeted" sensory stimulation, and 2. "augmented" functional mobility activities.

Considerations in the Application of Manual Techniques and Handling of Canine Patients
Therapeutic handling is integral to both the NDT and PNF approach during examination and treatment. Handling allows the therapist to perceive the patient's response to changes in posture and movement and to facilitate postural control and desirable movement patterns, or inhibit undesirable movement patterns that could detract from the functional goal or lead to undesired compensations. A primary goal of handling is to facilitate proper alignment, as is necessary for efficient functional movement.

Additionally, when handling the canine patient, the therapist should:

- Consider the patient with regards to his level of comfort, fear, pain, and/or anxiety. (As well, consider that of the client, as the patient will be acutely responsive to the client's reaction.)
- Approach from behind. Avoid placing yourself in the line of fire.
- Support the injured part (eg. spine, neck).
- Maintain contact (once it is introduced).
- Consider the influence of sensory input (eg. from the environment or gravity).
- Consider that hair and fur provide additional sensory input.
- Remember that the tail is "another extremity" with a direct route to the spine and nervous system.
- Avoid restraint and pain at all costs. Pain is inhibitory. Restraint will not encourage patient cooperation.

Finally, it is important ALWAYS, regardless of the NDT or PNF technique or treatment performed, to re-educate the patient with a functional, meaningful activity immediately following the manual treatment, so to enhance motor learning. Massed practice is utilized early, progressing to distributed practice. Additionally, application of NDT or PNF-based treatments and home activities in varied environments will enhance motor learning, leading to more efficiency in treatment and, potentially, a more complete functional recovery.

External Adjuncts and Assistive Devices

In addition to handling techniques, external adjuncts and assistive devices are of significant importance so that the patient can attain and maintain proper alignment when away from the therapist and in the home or community. Increased duration in postures with appropriate alignment improves the chances of favorable outcomes with regards to return to function. Some external adjuncts and assistive devices utilized in canine neurorehabilitation are TheraTogs, carts/wheelchairs, slings/harnesses, strollers, therapeutic tape (eg. kinesiotape, strapping tape), and orthotics/splints.

TheraTogs are a therapeutic undergarment and strapping system used by individuals with a sensorimotor impairment. They are a modality which can improve postural alignment and stability, enhance movement and joint stability, and provide a prolonged stretch. TheraTogs are designed to be customized by therapists to address the unique needs of their clients in an effort to promote positive biomechanical changes. They are to be used both in therapy sessions and between therapy sessions to provide additional hours of therapeutic benefit. This is especially advantageous in the canine patient where posture cannot be easily corrected with verbal cues and also where financial constraints may limit the amount time canine clients may receive direct sessions with a therapist.

The use of *orthotics*, "an externally applied device used to modify the structural and functional characteristics of the neuromuscular and skeletal system," is a readily accepted component of the approach to the human patient with a neurophysiologic condition. Orthotics are also used as therapeutic tools to promote optimal biomechanical alignment and resultant more efficient functional movement in the canine client. Ideally, orthotics used in the canine client are custom-made through consultation with the physical therapist, orthotist, and family to produce the most effective device for enhancing functional goals.

Carts, analogous to wheelchairs for human patients, can provide a customized mobility device as well as a tool for optimizing postural alignment, with an appropriate evaluation, measurement, construction, and application of the device. The optimization of postural alignment can only be achieved through an assessment identifying both the appropriate type of cart, appropriate fit, and appropriate modifications as necessary. After a thorough assessment by a physical therapist, the family can be instructed in proper donning/doffing of the cart, appropriate amount of time in the cart, and appropriate use of the cart (i.e. mobility versus support for postural exercises).

S*trollers* are also mobility devices that allow for passive transport of the canine client when distance, physical condition of the canine client, or other particular specifications would preclude use of a cart. When used with a canine patient with a neurophysiologic condition, it is of utmost importance for continuation of therapeutic principles and goals of postural alignment and neuroplasticity that the patient be positioned appropriately in anatomical alignment. Given the options that are currently on the market, the therapist will have to be creative in determining how best to achieve the goals of positioning in the stroller, keeping in mind the ability of the family to replicate the positioning effectively and correctly each time the device is used.

It is expected that, as there are technological advancements in adjuncts and assistive devices for human patients in neuro-rehabilitation, these may be modified to potentially assist the recovery of

canine patients from neurologic injury as well. In the same manner, the overall approach to rehabilitation will evolve, benefitting human and canine patients alike.

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