Initiation and Stimulation of Functional Movement and System Mechanics

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The human body, at its peak, moves fluidly in three-dimensional space maintaining a balance and opposition to gravity. The development of complex movements begins in infancy and builds based upon exploration of limb movement, followed by trunk involvement and ultimately whole body movements (ie. walking). System mechanics binds this progression of movement development. The authors define system mechanics as the combination of movements, external stimuli and neurological organization that cooperate to result in movement. This concept of system mechanics intersects neuromechanics and functional anatomy. The principles of neuromechanics provide a framework for understanding movements in individuals with a healthy nervous system and how that differs in a system with motor deficits.

Neuromechanical studies are aimed at understanding the required interaction of neural, biomechanical and environmental stimuli that result in purposeful movements. Such studies offer an external understanding of how movement occurs and suggests external applications to alter movement patterns for rehabilitative purposes. Functional anatomy describes movement as the sum of anatomical parts. In this work, the authors will describe an extrapolation of the idea of neuromechanics and functional anatomy where movement can be reorganized following the presentation of variable rotational motor patterns.

Rotation stimulates the brain to begin learning from the environment by reacting to the environment. Rotation, which creates torque within a movement, alters the foundation of movement. Without rotation, all movement would be linear \((P = mv)\) where \(P\) = momentum, \(m\) = mass and \(v\) = velocity. This equation describes a fixed object moving from point A to point B in a straight, bent, or orbital cycle derived from a fixed point of movement. Movement of the body does not originate from a single fixed point but from multiple locations either singularly or in combination. The more rotation available to an object, the greater the incremental variability in positioning. Variable positioning creates the total range of motion for a joint or limb. By introducing small rotational variations, the overall freedom of movement improves thereby altering the underlying neural pathways responsible for movement of the joint or limb.

For any motor task, there is generally a large number of solutions that can produce similar or functionally-equivalent behaviors. Therefore, movements have no single correct or optimal pattern which creates a robust system that can adapt to different or changing conditions. Variations in movement solutions and variability in movements is accounted for by the concept of motor abundance. Within the multiple available motor solutions, some may prove more advantageous to the system in energy requirements or stability. Muscle activation patterns have complex and nonlinear relationships to biomechanical functions and finding the optimal solution may prove difficult. By identifying and reinforcing rotation within a movement, the range of motion is increased. An increased range of motion results in a greater capacity for increasingly complex movements.

Observation of a person with injury to the neurological system reveals more obvious signs of difficulties in managing momentum. In this case, the person is slower in the ability to place the feet under the pelvis to attain the standing position. There is also a noticeable latency in the time required for mental and motor processing. The person will be mentally ready to stand, but require additional time to move the feet into position and then use momentum to stand. The action of standing requires rotation in at least 3 major joints and several smaller, more subtle places within the body. First the person must rotate
up onto the pelvis to lean forward in preparation. As standing begins, both the knees and ankles must rotate; the major lower body rotations required to stand. Additionally, the tarsals and metatarsals rotate to balance the body and the calcaneus creates counterbalance to the movement. The phalanges rotate through their length to provide stability in standing. If any of those rotations, large or small, fail or falter, the motion of standing becomes difficult or impossible. Some of these characteristics are the result of the neurological impairment and others result from the traditional management of orthopedic maladies. For example, in the case of a person who has a rod in the leg or artificial knee, the brain loses availability of the original movement pattern. In this case, the system employs the idea of motor abundance to create a new way to move. However, the new movement lacks the torque and rotation of the pre-surgical movement which leads to overcompensation of the system to integrate movement lacking rotation. Similar difficulties can occur without surgical intervention in response to trauma, injury, or progression of a disease state or process.

Comparing the femur from a typical adult to that of an adult with severe cerebral palsy (CP), the bone from the typical adult torqued during growth whereas the femur of an adult with CP the femur remained straight with less mass. Conventional wisdom suggests this is the result of the pull on the bone from the muscles. Notably, in a person with CP, the femur lacks rotation during development. Therefore, proper femur formation cannot be solely the effect of muscle mass. A person with CP has a greater muscular pull on the femur from the nearly continuous firing of spastic muscles. Conversely, a system with CP is not innately presented with torque through experience or exploration. Babies who will later be diagnosed with CP are much more static in their environment and do not explore movement. This results in a lack of momentum from birth which alters the relationship of the body with gravity. The Einstein theory of mass suggests that mass must curve, or more precisely, mass must have torque. In the body, the mass of the body must curve (have torque) to create a relationship with gravity and in three-dimensional space. A baby that lacks this exploration has an improper relationship to gravity and is often startled with movement or unable to lay in a supine position. All movement develops first from the relationship of the body to gravity. Thus, the movement does not develop properly if the brain cannot integrate or organize movements due to a lack of experience. To gain this experience, a system must generate momentum to create or continue movement.

Any body part can generate the momentum. Momentum is a reaction to the movement stimulus. Here examine the movement of an infant. Momentum without torque results in a body without proprioception and the infant can only react with spasticity or static positioning (with challenges in between). A healthy infant will glance slightly to the right and gently counterbalance through the left. With exploration and experience, the movements of an infant will grow larger and more accurate as the child ages. Neurobiological research shows that early experiences and stimulation are critical for optimal brain development, suggesting the considerable capacity of early intervention to affect the child. The brain develops by an “experience-dependent” process, where experience activates certain pathways in the brain and not others. Experiences early in life are especially crucial in organizing the brain’s basic structures, as they create the neural foundation for all subsequent development and behavior. Lack of stimulation or experience leads to cell death in a process called “pruning” whereby pathways that are not used are eliminated.

It is important to note that the rotational principles and gentle touch of the Movement lesson method can be applied to any part of the body, though for simplicity, the authors have focused commentary in this paper on the lower extremities. This modality makes use of a very gentle touch meant to be an extension of the system rather than an external force. To understand this movement, visualize holding a bowl of water. The goal of this method is to create a rotation of the water without disturbing the water surface or creating turbulence. The bowl should rotate around the water. If the touch is too quick or too forceful, the force will transfer onto the water thereby creating waves. Waves in the bowl translate to startles or contraction in the neurological system. In this method, the end point often has several experiential parts required prior to working on “the goal”. For example, if the goal is to improve or induce ambulation, traditional therapeutic modalities begin by pushing the foot/leg forward and then down on the ground, often in a walker with orthotics. In Movement Lesson®, work begins in the pelvis and progresses down the leg. Before a system can sit, stand, crawl or walk, the pelvis must rotate in space. Pelvic rotations around the coccyx create the freedom to turn and stand (e.g. getting out of a car). In its optimal form, the pelvis rotates as a gyroscope in response to gravity as a main component to remaining upright.

Subtle variations are then added to increase the complexity. When the practitioner is in contact with the system, the practitioner must engage their own system in the movement and counterbalance in order to create movement in the system rather than movement in opposition to an applied force. For example, if the practitioner is working the pelvis through a figure eight motion, as the left side of the recipient’s pelvis rotates up and back, the practitioner must have a forward motion of the rib cage and arm extension while the left arm and ribs of the practitioner rotate back. These movements reverse as the recipient’s left hip rotates forward and down and the right hip rotates up and back. This creates a balance and counterbalance in the movement and the system experiences a new movement which leads to learning.
Another example contrasting the body through the use of static positioning with subtle dynamic movement (Movement Lesson*). In traditional modalities, a shortened Achilles tendon and tight gastrocnemius are addressed through a static stretch using an ankle foot orthotic (AFO) to hold the foot in a neutral position at a 90 degree angle. The orthotics are also used to stand and walk. This static positioning does not allow for the dynamic use of the entire ankle and leg system. By removing the rotation in the ankle, it alters the rotation throughout the system and increases the difficulty in standing or walking. For proper standing or ambulation, the calcaneus must rotate slightly left and right in opposition to the metatarsals of the foot. The metatarsals then rotate and spread as the toes make contact with the ground. A foot locked into an AFO has no heel movement available nor can the metatarsals move freely. An AFO locks the ankle and the foot into a single unit. The foot contains one quarter of the bones in the human body. One would postulate that optimal function would make use of those joints and the available movement rather than hindering those functions. AFOs also remove the torque in the joint. The summation of the experience of pelvic rotation and the rotations of the ankle foot complex results in a system with a better organization of standing and ambulation.

This application of gentle touch, rotation and counterbalance through the practitioner are the foundation of this work and can be applied throughout the system to improve and organize movement through experience. The most important thing to note here is the subtlety of the movement. This practice is not about effort on the part of the practitioner or the recipient. It is rather, a reciprocal interaction or conversation between the two. In this way, the practitioner becomes a part of the system rather than an external force. It is through this communication that the brain of the recipient begins to learn and organize new or more optimal movements. Such alterations in brain function based on experience is known as neuroplasticity. Broadly, neuroplasticity is the ability of the nervous system to respond to intrinsic and extrinsic stimuli by reorganizing structure and function from molecular changes to systems or behavior. This process can occur in development, in response to environmental stimuli, through the progression of a disease state in following a therapeutic intervention. When a system repeatedly performs an activity, or accesses a memory, the underlying circuitry, or networks fire together to create a neural network. Here, the authors describe a new way of organizing or initiating movement. Movement develops complexity through experience and is based upon torque derived from rotation. Experience of movement drives the neural circuitry to create connections for the repetition of the movement. Functional movement and system mechanics underlying movement require a rotational axis to create the acceleration necessary to oppose gravity. System mechanics are not centered on the amount or functionality of the muscles, but rather the rotation of the underlying skeletal structures. Muscles are recruited to complete or refine the movements rather that the point of initiation. Changes in movement patterns and system mechanics are outward expressions of underlying changes in the brain.

Further studies involving the initiation and stimulation of functional developmental movement patterns through the system mechanics of infants, children and adults are strongly recommended. However, specific atypical patterning that begins to evolve, particularly in children requiring early intervention for short-term and long-term care, can be redirected through Movement Lesson to considerably lessen the severity of such movement disorders. By utilizing the concepts presented, professionals can significantly enhance their practice to reduce pain and improve movement patterns in any individual seeking assistance.

References