

THINK BIG, FROM VOICE TO LIMB MOVEMENT THERAPY

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ABSTRACT

We will test the efficacy of an innovative physical therapy treatment technique based upon the Lee Silverman Voice Treatment (LSVT[®]). Thus, people with PD will undergo intensive practice of high effort/large amplitude arm movements while focusing on the sensory awareness of “movement bigness.” As LSVT[®] uses extensive practice and feedback/knowledge of results to teach patients the amount of effort needed to consistently perform “louder” voice, we will use similar motor learning techniques to teach patients the amount of effort needed to consistently perform “bigger” movements. Speech studies have shown that a treatment with a simple focus (think loud) may generalize to affect motor output in other systems (e.g., articulation, speaking rate, swallowing, respiratory mechanics). Thus, we predict that learning to perform bigger arm movements will not only improve arm function during everyday activities, but the effects will generalize to lower limb function and speech motor control.

[1] INTRODUCTION/BACKGROUND

Advances have recently occurred in drug therapies and deep brain stimulation for individuals with Parkinson disease (PD). Although these therapies have diminished symptoms and prolonged the onset of disability, some symptoms are not improved and most symptoms inevitably become more severe [1,2,3]. Hence, medication and surgical intervention alone are not adequate treatment for PD. Movement rehabilitation and speech therapy techniques are needed, therefore, as an adjunct, to medical therapies to preserve function for as long as possible, to improve the quality of life, and to prevent the predictable chronic sequelae as the disease progresses [4,5].

What interventions in movement rehabilitation have been used to reduce or retard the physical disabilities associated with PD? Rehabilitation procedures have traditionally focused on general exercise programs to address the list of problems in PD including exercises for cardiovascular fitness, strength, range of motion, posture, gait, coordination, and balance [6,4,5]. Additional approaches have been advocated to address specific motor deficits of PD, such as relaxation techniques and an emphasis on axial rotation to reduce rigidity [7,4]. However, most of the exercises could be applied to any sedentary individual [8]. Moreover, the efficacy of these types of physical therapy interventions has been minimal. Controlled studies have demonstrated only small and short-term improvements in motor performance and functional activities [9,10,11,12,13,14]. Another study evaluating specific physical therapy techniques of proprioceptive neuromuscular facilitation, Bobath, and conductive education, showed no

improvement when used with individuals with PD [15]. Together, these studies suggest that the efficacy of these more general approaches is limited and thus, interventions are needed to directly address symptoms of PD (hypokinesia, akinesia, rigidity).

In fact, several studies have demonstrated efficacy of specialized behavioral strategies that directly address the symptoms of PD. For example, individuals with PD were taught to use external cues (visual, auditory or tactile) to elicit larger steps, faster walking speeds, improved posture and rotation, and to overcome freezing [16,17,10,18,19,20,21]. In other studies, the patients were taught to use internal cues, such as rehearsal or dividing a complex movement into several simple components, to replace automaticity with conscious effort [22,23,24]. Although these specialized approaches have helped patients, they are limited. External cues are difficult to provide when outside the home. Both external and internal cues are dependent on the context and the specific task, and consequently, patients are required to remember multiple cues or instructions in order to deal with the range of everyday activities and situations.

In contrast, LSVT[®] has been established for treatment of speech and voice disorders in individuals with PD and has documented amazing success [25,26,27,28,29]. It addresses many of the limitations of the various movement rehabilitation approaches. That is, it was developed specifically to address the movement deficits in individuals with PD, and it has a simple focus that is applicable for any context. The LSVT[®] approach focuses on only one goal, “loudness.” Yet upon completion of the program, speech is not only louder, but more intelligible [30]. This simple focus on only one goal is supported by studies showing that individuals with PD have difficulty with attention-demanding, complex tasks [31,32,33,34,35,36]. The use of focused attention on one subcomponent of movement has also been advocated for gait, turning, and rising from a chair [17,37,24]. Despite this simple approach, studies have demonstrated that LSVT[®] treatment results in retention of vocal loudness above pretreatment levels for up to two years after treatment [38,29].

Given the success of LSVT[®], it is surprising that this model has not been applied to movement rehabilitation. Thus, this project will take a proven treatment method from one motor system (speech) and apply it to another motor system (limb). From a motor control perspective, this project may provide clarification of the similarities and differences in speech motor and limb motor systems. LSVT[®] is easily applied to limb movements because it is based upon established pathophysiological mechanisms to explain the movement disorders that occur in individuals with PD. That is,

individuals with PD are generally unable to activate their muscles adequately [39], and although they are capable of modulating their agonist activity, they underestimate the absolute muscle activity required for a particular movement output [40]. Thus, the treatment concepts are aimed at teaching the patients to use high phonatory effort to increase drive to the respiratory and laryngeal systems to increase the amplitude of vocal output (loudness), thereby alleviating the effect of hypokinesia [41]. Thus, as LSVT[®] focuses exclusively on training “loudness,” we will focus on training the analogous limb attribute, “bigness.” We will test hypotheses to determine if 1) individuals with PD learn to increase their motor output (bigness) to overcome the movement deficits of hypokinesia and bradykinesia and 2) does this effortful behavior become more automatic (less effortful). Hence, we will measure perceived effort pre- and post-intervention during a standardized task and correlate it with improvements in movement amplitude, speed, or function.

We have chosen the strategy of “think big” rather than “think fast” because studies have suggested that hypokinesia is the underlying deficit in Parkinson gait and upper limb reaching movements [17,40,42,43]. In other words, by addressing hypokinesia, other deficits such as bradykinesia are also improved. Much of the intervention literature supports this approach. For instance, when individuals with PD were given cues for increasing amplitude during gait, walking velocity increased to that of normal subjects [17,43]. In contrast, when individuals with PD were instructed to focus explicitly on speed, amplitude of movement never approached normal levels. Indeed, stride length was reduced when patients were asked to match their speed of walking with a metronome. Similarly, during reaching movements, our own data has suggested that shoulder joint amplitudes were reduced when individuals with PD matched their speeds with a metronome [44]. Moreover, others have shown that when individuals with PD are instructed to move faster than their preferred speed, forces become more variable [45,46] or accuracy may be compromised [47,48,49]. The literature on limb movement, therefore, suggests that a LSVT[®] approach, which focuses on amplitude in order to bring about other functional improvements, will also apply for arm and leg movements.

While a LSVT[®] approach focuses on one goal for treatment, it uses a motor learning approach to affect performance and facilitate learning. It involves intense practice of a loud voice and continual patient education concerning knowledge of results regarding loudness. Thus, patients learn a new relationship between effort and the actual motor output in order to produce a louder voice (and in our case, bigger movements). Interestingly, a recent Positron Emission Tomography (PET) study suggests that with practice, effortful behavior may become more automatic (less effortful) [50,51]. These authors showed that in five patients with mild PD that participated in LSVT[®] therapy, a reduction of hypophonia (increased loudness) was accompanied by a shift of activation from cortical-premotor areas (pre-LSVT) to basal ganglia, anterior insula areas (post-LSVT). This physiological evidence for learning is also supported by several behavioral studies that have shown that individuals with PD are capable of improving performance with intense practice [52,53,54,55]. In fact, Yekuteil et al. (1991), using a similar educational/knowledge of results approach that is advocated in LSVT[®], showed that

patients could learn to consciously focus attention on body mechanics required for whole body movement during tasks like walking, turning, and rising from a chair. Interestingly, Yekuteil et al. showed that speed of movement also improved, despite a conscious focus on body mechanics.

Another purpose of this proposal is to bridge the gap between the basic neurobiology of complex movements and the clinical application of movement training in rehabilitation. In the last decade, basic science understanding of limb movement has realized that the complexity of the biomechanical interactions between linked segments requires that a limb be controlled as a whole and not as a summation of separate controls at each joint [56,57,58]. Moreover, it has been demonstrated that muscles are often activated in non-intuitive patterns, such as flexors being activated while a joint is extending because of mechanical interactions transferred from a neighboring joint [59,60,61]. These shifts in basic understanding have yet to be translated into a significant change in movement rehabilitation.

In this proposal, we will apply the recent principles of multijoint control to treatment and evaluation. First, the arm-LSVT[®] approach, by focusing on bigness, encompasses the idea of control of the whole limb. Second, the limb tasks that will be used in this study will involve mechanical interactions between the joints. Individuals with PD have greatest difficulty with complex movements [31,62] and a recent study suggests that they have specific deficits in controlling mechanical interactions of complex movements [63,64,65]. In this manner, the arm-LSVT approach using complex movements incorporates the modern view of motor control into a treatment strategy. Third, the new ideas regarding control of multijoint limb movement are also important for the measurement of movement, both in the research laboratory and as outcome assessments in rehabilitation. The Unified Parkinson Disease Rating Scale (UPDRS) [66] and the Hoehn and Yahr Scale (HYS) [67] are standardized clinical measures that can adequately capture a patient’s general level of functioning and change in symptoms. However, these scales do not provide specific data on the control of limb movement. In this study, kinematic and kinetic measures of arm movement will be used in addition to the UPDRS and HYS, in order to document changes in multijoint control.

This study has the potential to identify innovative treatment techniques that could induce a fundamental shift in movement rehabilitation for individuals with PD. From this initial proposal, several issues would need further exploration, such as the retention of treatment effects and the generalizability of the treatment to other movements (does arm training generalize to leg and speech movements, and vice versa, does speech training generalize to arm and leg movements). If the results demonstrate that an arm-LSVT approach improves limb function, future directions would work to develop a standardized protocol that can be used for training physical therapists. Moreover, the assessment techniques of this proposal could become important for adjunct clinical assessments that provide information on the physiological mechanisms of hypokinesia and bradykinesia. Both the training and evaluation, specific to PD, would be exciting new tools and methods for the movement rehabilitation field.

2. REFERENCES

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