Immediate Effect of Pelvic Proprioceptive Neuromuscular Facilitation (PNF) Technique on Hemiplegic Gait

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The immediate effect of proprioceptive neuromuscular facilitation (PNF) emphasizing proximal movement control on hemiplegic velocity and cadence was investigated. Six adult hemiplegic patients meeting the selection criteria participated in the study. The study was a within subject, between condition comparison study. Each subject received a control and an experimental condition for 30 minutes each. The sequence was randomly assigned. The subject walked for 18.3 meters (60 feet), rested for two minutes and walked for 18.3 meters again for both pre- and post-evaluation. The velocity and cadence were calculated. The paired t-test was used for comparing the change (α =.05). The patients showed a significant improvement in velocity immediately after the PNF treatment. The improvement of cadence was not significant. Proprioceptive neuromuscular facilitation approaches may be a measure to improve the gait of hemiplegic patients.

Key Words: Immediate effect, Pelvic PNF, Hemiplegic gait.

The functional recovery of the hemiplegic patient is a challenge to clinicians[1]. Walking ability of the hemiplegic patient may be an index of a patient's recovery, and the improvement of walking ability is frequently the primary rehabilitation goal for the hemiplegic patient[2]. The proprioceptive neuromuscular facilitation (PNF) approach to therapeutic exercise has gained clinical acceptance and usage during the past twenty years. However, the scientific credibility is limited[3,4]. Clinically, hemiplegic patients show improvement in velocity and cadence of gait immediately after PNF treatment[5]. Some studies have reported the immediate effect of PNF on range of motion and muscle strength[6,7]. No study has documented the immediate effect of PNF treatment on hemiplegic gait. The question to be answered is: Is the gait of the hemiplegic patient immediately affected by PNF treatment?

The classic sign of cerebral vascular disease, which is defined as a local disturbance in blood supply of the brain, is hemiplegia[8]. Most hemiplegic patients show varying degrees of spasticity on the affected side, which includes the pelvis and the extremity[9,10].

Inadequate control of pelvic motion has been identified by Suvinelli as a common gait problem[11]. Resisted or assisted exercises are suggested treatment techniques to stimulate pelvic motion. Bobath has identified that "the spasticity of the limb can be influenced and reduced from the proximal key point control"[9]. The proximal points include the pelvic girdle. Bobath also suggested pelvic rotatory movement to reduce extensor spasticity of the lower extremity of the hemiplegic patient[9]. The decrease of extensor spasticity of the leg, secondary to proximal pelvic movement is said to facilitate ease and normality of leg movement[9,10].

Numerous peripheral afferent stimuli-cutaneous, proprioceptive, and even mechanical-may cause reflex inhibition of spasticity[11]. Proprioceptive neuromuscular facilitation (PNF) incorporates cutaneous, proprioceptive and mechanical stimulation through manual contact, resistance and stretch to the pelvis. This stimulation reflexly inhibits spasticity of the lower extremity and, secondarily, may affect the velocity and cadence of gait.

The gait of the hemiplegic patient can be evaluated subjectively and objectively(12). One of the objective methods is a temporal-distance (TD) measure. The temporal-distance measure, using measurements such as velocity and cadence, can provide quantification of changes of gait and comparison of the outcomes of locomotor function improvement across treatment(12).

Velocity is defined as the meters walked per second, and the cadence is defined as the steps walked per minute(12). Spasticity is the main factor restricting walking velocity and cadence of the hemiplegic patient(13). Therefore, increase in velocity and cadence within a certain distance may be regarded as improvement of spastic hemiplegic gait(13). The velocity and cadence were chosen for measuring the change of walking ability of the hemiplegic patient in this study due to simplicity, reliability and meaningfulness of the measurement(13).

The null hypothesis for this study is: There is no difference in a) change of walking velocity or b) change of cadence between hemiplegic patients immediately after receiving proprioceptive neuromuscular facilitation (PNF) treatment and those same patients immediately after receiving the control condition.

METHOD

Design

The study was a within-subject, between condition comparison study. Each subject received a control and an experimental condition. The experimental condition consisted of 30 minutes PNF treatment, and the control condition was just sidelying on the mat for 30 minutes. The testing sessions were carried out immediately before and after each condition. The sequence of the conditions was randomly assigned to the patient. The two sequences were a) experimental condition followed by the control condition, or b) control condition followed by the experimental condition. The two conditions were two days apart.

Sample

Six adult hemiplegic patients (4 men, 2 women) from out-patient services of the Center for Rehabilitation Medicine, Emory University Hospital served as subjects. The age of the patients was between 51 and 80 (average 60.6 years old). The method of sampling was accidental. The sample population was chosen based on the following criteria: Hemiplegic patient secondary to cerebrovascular disease; at least in Brunnstrom motor recovery stage 3 of lower extremity with extensor components(10); can walk out of parallel bars without manual assistance at least 18.3 meters (60 feet) with or without assisted device; no previous pelvic PNF treatment; no functional limitation of passive range of motion in lower extremity; no receptive aphasia and intact proprioception. All subjects signed an informed consent. Of the six patients, four were right-sided hemiplegics and two were left hemiplegics. All patients were diagnosed as having cerebral infarct. The duration post-onset was between 5 and 10 months (average = 6.5 months).

Measurement

Each patient had 4 testing sessions. Two were pre-treatment testing sessions, and two were post-treatment testing sessions. The testing sessions were carried out immediately before and after the treatment and control conditions. Each testing session included two trials of walking a distance of 18.3 meters out of the parallel bars. During the walking, the total time (in seconds) and total steps were recorded by using a stop-watch and counting heel strikes. Resting time between the two trials was two minutes. The averaged values of the two trails were used for data collection. The change of walking velocity and cadence were calculated for statistical analysis. The change was defined as the post-treatment value minus the pre-treatment value.

The formula for velocity was distance (meters) divided by time (seconds). The cadence equaled the total steps divided by total time walked (in minutes)(12).

Side of hemiplegia and diagnosis of the patient were obtained from the medical chart.

Data such as patient's age, sex, months since onset were collected by interviewing the patient before and after the treatment. Subject responses were compared with the information from the patient medical chart to assure reliability. The recovery stage of the lower extremity of the patient was obtained from the screening test by using Brunnstrom recovery stage[10].

Intra- and inter-rater reliability of all measured variables, treatment procedures and data conversion were established and maintained throughout the study (r = 0.90 to 1.00).

Procedures

Patients were selected for the study according to the selection criteria. Next, patients were randomly assigned to one of the two sequences of conditions. Each patient in this study received only one experimental and one control condition. Before starting the treatment, the treatment aim and method were explained to the patient and informed consent obtained. The patient then walked for 18.3 meters, rested for two minutes and then walked for 18.3 meters again. The walking time and total steps for both walks were recorded by the experimenter (pre-test). Immediately following the evaluation, the patient, if in the experimental condition, received rhythmic initiation, slow reversal and agonistic reversal PNF techniques. These PNF techniques included the elements of patterns of movement, patient position, physical therapist's position, manual contact, maximal resistance, stretch, range of the movement, irradiation and verbal/visual cues. Total treatment time was 30 minutes. (See Appendix for treatment protocol). Immediately after the treatment, the patient completed the 18.3-meter walk, rested for two minutes and repeated the 18.3-meter walk (post-test).

If in the control condition, the patient rested in the sidelying position on the unaffected side with both hips bent to 100 degrees, knees bent to 45 degrees and neck bent to 30 degrees for 30 minutes following the pretest evaluation. Immediately after the control condition, the patient completed the post-test evaluation.

Data Analysis

The paired t-test was used for comparing the change of velocity and cadence. Mean of difference between conditions, standard deviation of the difference and degrees of freedom were calculated for the paired t-test [14]. Alpha (α) level was 0.05. The averaged value of patient's age and time since onset were also calculated.

RESULTS

The null hypothesis of this study was: There is no difference in a) change of velocity b) change of cadence between hemiplegic patients immediately after receiving proprioceptive neuromuscular facilitation (PNF) treatment and in those same patients immediately after receiving a control condition.

All patients in the study demonstrated increased walking velocity after PNF treatment, and all patients, except one, demonstrated decreased walking velocity after the control condition (see Table 1). The paired t-test for velocity demonstrated a statistically significant difference ($p<0.05$) in change in velocity between the two conditions (see Table 3). The null hypothesis for velocity was not supported.

All patients also demonstrated increased cadence after PNF treatment (see Table 2). The paired t-test for cadence demonstrated a statistically significant difference at $p = 0.10$, but not at the criterion 0.05 level (see Table 3). The null hypothesis for cadence was supported.

DISCUSSION

The present study is a preliminary attempt to determine the influence of PNF techniques emphasizing pelvic movement on gait of hemiplegic patients. The results indicate an immediate improvement in the walking velocity in the experimental condition versus the control condition. An immediate improvement in the cadence after the experimental condition was observed but was not statistically significant.

The mechanism by which the PNF treatment may have produced the increased walking velocity and cadence has not been investigated. Reduction of distal spasticity

TABLE 1

Pretest to Posttest Changes in Velocity

Subjects	Improvement (meters/sec)	
	PNF Condition	Control Condition
1	0.0213	-0.0007
2	0.0114	-0.0050
3	0.0403	-0.0035
4	0.0392	0.0144
5	0.0990	-0.0033
6	0.0174	-0.0004
$\bar{X}$(SD)	0.0381 (±0.0321)	0.0003 (±0.0072)

TABLE 2

Pretest to Posttest Changes in Cadence

Subjects	Improvement (steps/min)	
	PNF Condition	Control Condition
1	2.38	-0.25
2	0.18	1.57
3	3.23	1.14
4	1.99	0.06
5	6.84	0.00
6	1.95	0.00
$\bar{X}$ (SD)	2.76 (±2.23)	0.42 (±0.74)

TABLE 3

Paired t-test of Change in Velocity and Change in Cadence Between PNF and Control Condition

	PNF	Control	Difference	t-value	p-value
Velocity					
$\bar{X}$	0.0381	0.0003	0.0378		
SD	0.0321	0.0072	0.0331	2.800	<0.05
Cadence					
$\bar{X}$	2.76	0.42	2.34		
SD	2.23	0.74	2.63	2.1869	<0.10

of the hemiplegic patient by facilitating normal proximal movement has been demonstrated[9]. However, the mechanism by which proximal movement affects distal movement is not clear. Proximal key points may have a greater receptive field representation in the central cortex than distal points[15]. Proximal joint representation surrounds distal joint in a contiguous fashion[15]. Thus, the anatomical presentation may allow for dispersion of normal impulses from proximal to distal areas[11,15]. The passive component of the rhythmic initiation PNF technique is said to reduce proximal spasticity by decreasing the input from the muscle and joint receptors to the reticular formation, vestibular system and cortex. This is secondary to adaptation or accommodation of the muscle and joint receptors[11]. The active component of rhythmic initiation, slow reversal and agonistic reversal PNF techniques may also contribute to decrease proximal spasticity through reciprocal inhibition. The reciprocal inhibition is probably due to the firing of Golgi tendon organs and Renshaw cells [11]. Once the tone has been decreased, normal reciprocal pelvic (proximal) movement may be reinforced by the techniques above. The facilitating effect of these PNF techniques may be due to increased spindle afferent firing by stretch reflex, biasing of gamma system, successive induction and central programming mechanisms[11]. The elements in the PNF procedure, such as manual contact, stretch, and resistance etc, superimposed on the above techniques may activate skin, muscle and joint receptors. The activated receptors will increase afferent inputs to spinal cord, reticular formation and the associated area in the cortex, which further reinforces the normal pelvic movement [4,11].

The increase of velocity and cadence are equally important in patient's gait ability [12]. In the present study, the spasticity has been reduced enough to free the leg swing and allow statistically significant increase in velocity. However, the decrease of spasticity is probably not enough to make the cadence statistically improved in the present study. The improvement of cadence may require further training in weight bearing on the affected side, weight shifting, trunk control and walking balance. The improvement of cadence may be a long-term treatment effect and may require administration of additional techniques or procedures [11,13,16].

An important component of the present study was to develop a standard PNF-pelvic pattern treatment protocol. A standard treatment protocol is essential when systematically evaluating the effect of different therapeutic techniques. The protocol also provides a quideline for clinicians when doing routine treatment.

This study used a small, non-random sample and investigated only the immediate effect of PNF treatment. Future study should incorporate: a) a large, random sample to confirm and allow generalization of the present results, b) investigation of the relationship between the duration of the treatment and functional gains, and c) long-term effects of PNF treatment. Studies, investigating treatment effects in both acute and chronic hemiplegic patient, in patients with various etiologies of hemiplegia and in varying age groups are also needed.

CONCLUSIONS

The study indicates that proprioceptive neuromuscular facilitation, emphasizing pelvic (proximal) control, may improve walking velocity and the cadence in hemiplegic patients. The treatment may decrease the spasticity and increase normal reciprocal movement.

APPENDIX

Protocol for Proprioceptive Neuromuscular Facilitation (PNF) Treatment [11,17,18]

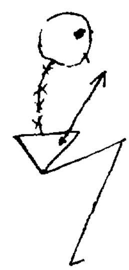
The techniques and elements in PNF described below are used in the proposed study as the independent variable.

1. Elements
   1) Patterns of movement
      Pelvic anterior elevation of the affected side

      The characteristics of this pattern are: cross midline, rotatory, full elongation of underlying muscles, end-point feeling secondary to the full elongation, and out of abnormal synergistic pattern.

      The patient is lying on his sound side with both legs bent to 100° hip flexion; 45° knee flexion and neck bent to 30° to start the pattern. In this position, the anterior superior iliac spine (ASIS) is viewed as pointing to twelve o'clock in a clock. While doing the pattern, the ASIS is facilitated to move along the one o'clock direction with rotatory movement of the pelvis and full elongation of the underlying muscles [11,17,18].

Movement of the pattern: at one o'clock direction



Anterior Superior Iliac Spine (ASIS)

   2) Patient position
      Sidelying on the unaffected side with both legs bent. (neck bent to 30°, hips bent to 100°, and knee bent to 45°) [11,17].
   3) Physical therapist's position
      The physical therapist stands (or kneels) behind the patient and in the direction of the pelvic movement of the patient [11,17].
   4) Manual contact
      The therapist's hands are overlapped and placed on the anterior iliac spine of the patient's pelvis. The area of manual

contact is as small as possible. The direction of manual contact is also in the direction of patient's anterior elevation pelvic movement(11,17).

5) Maximal resistance

Variable

The resistance is given according to patient's need in order to get a smooth and coordinated movement. The maximal resistance can be meant as assistance or resistance to the patient(11,17).

6) Stretch

The stretch is applied immediately and gently after the desired muscles have been fully elongated. (Before the patient starts to move)(11,17).

7) Appropriate part of the range

Variable

The therapist needs to try whatever part of the range, which is most facilitatory to the anterior elevation pattern of the pelvic movement, i.e. initial or terminal part of the range(11).

8) Irradiation

Bending the neck actively without resistance will be used for irradiation in the study(11,17).

9) Approximation/traction

Not used in this study.

10) Verbal/visual

Variable

The verbal and visual cues are used according to the patient's need; verbal cues must be specific, timed, and in keeping with desired movement, such as push or pull(17).

2. Techniques

Techniques used in this study are rhythmic initiation, slow reversal and agonistic reversals.

The sequence of applying the three techniques for facilitating the movement is rhythmic initiation for 10 minutes first, then the slow reversal for an additional 10 minutes and then the agonistic reversals for an additional 10 minutes. An alarm clock is used to count the time. The physical therapist will stop the technique if abnormal posture (abnormal synergy or spasticity) present in the patient, and do only the pelvic anterior elevation movement for the patient (passively). The passive movement will las until relaxation of the patient's abnorma posture begins. Another trial of the technique will continue after the relaxation t fulfill the time set for each technique.

1) Rhythmic initiation (RI)

"(1) Using the command of 'relax and let me move you' move the part first through the available range of motion of the pelvic anterior elevation pattern, then return the part through the antagonistic pattern.

(2) When the relaxation is achieved, using the command of 'now help me move you' have the client assist the movement for 3-4 repetitions.

(3) Using the command 'push' or 'pull' as appropriate superimpose resistance upon the movement, gradually increasing the resistance with the increase in client's response. Repeat for 3-4 repetitions.

(4) Have the client move the part actively through the agonistic and antagonistic patterns, independently "(18). for the remainder of 10 minutes.

2) Slow reversal

"(1) Move the client's body part to the lengthened range of the agonistic pattern. (anterior elevation of pelvis)

(2) Using the proper manual contacts and verbal cues, have the client perform an isotonic contraction of the agonistic pattern against maximal resistance, to the weak point in the range of motion.

(3) Switch manual contacts to the antagonistic pattern (pelvic posterior depression) and have the client perform an isotonic contraction of the antagonistic pattern against maximal resistance.

(4) Again switch manual contacts to the agonistic patterns and have the client move through as much of the range of motion of the pattern as possible "(18).

3) Agonistic reversal

"(1) Move the client's body part to the lengthened range of the desired pattern.

(2) Using the proper manual contacts and verbal cues, have the client perform a concentric isotonic contraction of the desired pattern, to the shortened range of the pattern.

(3) Using the command of 'make it hard for me to move you', have the client perform an eccentric contraction of the desired pattern; returning to the lengthened range of the pattern „(18).

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骨盆部位本體感受神經肌肉促導法對於中風病人步態的影響

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本體感受神經肌肉促導法（ proprioceptive Neuromuscular Facilitation ）是臨床上廣被接受及使用的一種運動治療。在臨床的觀察，中風病人在接受本體感受神經肌肉促導法後，走路的速度（ Velocity ）及步數（ Cadence ）都有進步，但尚未獲實際證明，本文就此加以研究。

骨盆控制不好，爲中風病人行走的主要問題，Bobath 認爲經由近身體中心重點控制（ proximal key point control）可影響及減低肢體的痙攣，所謂近身體中心重點控制即包括骨盆部份。腿部痙攣減低之後，可使腿部較易做正常的動作。

本文是用客觀方法－走路的速度及步數來評估中風病人走路進步的情形。本研究爲病人本身（ Within Subject ）做兩種情況（ between condition）比較的研究。六位病人接受此研究，每一位病人隨機地接受控制情況（ control condition ）或實驗情況（ experimental condition ）各卅分鐘，在接受研究任一情況之前及之後，都做步數評估。實驗情況爲病人側躺接受卅分鐘的骨盆部位本體感受神經肌肉促導法治療，而控制情況爲病人側躺卅分鐘下，不做任何治療。並採用paired t-test 來做統計分析。此研究結果爲：六位病人在接受骨盆部位本體感受神經肌肉促導法治療之後，走路的速度都有意義的增加（ $p<0.05$），六位病人也顯示步數的增加，但 $p=0.1$ 並無統計上的意義。

此篇爲一初步的嘗試，試圖研究骨盆部位本體感受神經肌肉促導法之治療，對於中風病人步態的影響。另外本文較重要的部份爲將此治療標準化，而治療標準化是做爲分析、統計、研究不同治療技術效果的基礎，也是對臨床工作者的一個指針。但本文爲一小的樣本群，爲了對我們目前所使用的治療技術更了解也更有信心，日後我們該朝著下列的方向，做更深入的研究報告。 1.增加樣本群以推展研究的結果；2.研究治療時期的長短及功能恢復的相關性；3.研究慢性期及急性期中風病人對本體感受神經肌肉促導法治療效果的異同；4.不同年齡層及不同中風病因是否有不同治療的結果。

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