Pelvic Exercise and Gait in Hemiplegia

The purpose of this study was to describe and compare the gait of 20 patients with hemiplegia secondary to cerebrovascular accident (CVA) before and after a treatment regimen of resisted pelvic motions. Ten women and 10 men were studied, with a mean age of 48 years and a mean duration post-CVA of two months. Nine subjects (45%) were right hemiplegic, and 11 subjects (55%) were left hemiplegic. Treatment consisted of four sets of five repetitions each of manually resisted pelvic anterior-elevation and posterior-depression movements on the involved side. An insole footswitch system, knee electrogoniometer, and force walking aid were used in gait analysis performed before treatment, immediately after treatment (posttest 1), and 30 minutes after treatment (posttest 2). Results showed significant overall improvement in gait in posttest 1 (p < .005) compared with the pretest. This improvement, however, was not maintained in posttest 2. Ten patients improved overall in posttest 1; only 4 patients also showed improvement in posttest 2. The major improvements seen immediately after treatment were observed in stance stability and limb advancement in the involved limb. More research is needed to identify an optimum treatment with carry-over using this technique. [Trueblood PR, Walker JM, Perry J, et al: Pelvic exercise and gait in hemiplegia. Phys Ther 69:18-26, 1989]

Key Words: Gait; Hemiplegia, gait; Neuromuscular facilitation; Proprioception.

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A variety of neurologically based techniques are used by physical therapists in the treatment of hemiplegic patients. Although these techniques are used widely, few studies have been reported in the literature validating these diverse approaches for specific conditions or problems.

Proprioceptive neuromuscular facilitation is a philosophy of treatment based on principles of neurophysiology. The principles of PNF were explained first by Kabat,1,2 based on Sherrington's work in muscle and nerve physiology. Kabat suggested that patterns of movements performed in combination with other facilitatory procedures result in enhanced voluntary responses.2 The PNF approach to treatment uses the principle (based on early phylogenetic and embryologic observations4,5) that control of motion proceeds from proximal to distal body regions.6 Facilitation of trunk control, therefore, is used to influence the extremities. If this treatment paradigm is valid, gaining control of and strengthening "normal" pelvic motions should improve lower extremity function.

One PNF activity used during treatment of hemiplegic patients is manual resistance to directed pelvic motions of anterior elevation and posterior depression.7 The patient is positioned
side lying and moves the pelvis up and forward and then down and backward. Electromyographic studies have not been conducted to determine which muscles work during this pattern. Based on anatomy, however, the prime movers appear to be the ipsilateral abdominal oblique muscles during pelvic anterior elevation and the contralateral abdominal oblique muscles during pelvic posterior depression.⑧

Studies testing the effectiveness of a PNF-based exercise regimen have been both conflicting⑨⑩ and supportive.⑪⑫⑬ No study was found on the use of resisted pelvic patterns to influence gait characteristics. Because PNF is widely taught and used by physical therapists, scientific demonstration of the effectiveness on these procedures is needed. The purpose of this study was to investigate whether significant improvements occur in the hemiplegic patient’s gait following a treatment of resistance to pelvic motions. Our hypothesis that pelvic exercise will improve the patient’s gait was based on the primary investigator’s (P.R.T.) clinical experience in the use of PNF philosophy for treatment of patients with cerebrovascular accidents (CVAs). We expected to be able to demonstrate some improvement in gait following the treatment regimen. We did not know whether this improvement would be measurable. We also expected no carry-over in the final posttest, again based on the primary investigator’s clinical experience.

**Method**

**Subjects**

We studied 20 hemiplegic patients (10 men, 10 women) from the Stroke Service at Rancho Los Amigos Medical Center (RLAMC) (Tab. 1). Nine subjects (45%) were right hemiplegic, and 11 subjects (55%) were left hemiplegic. Minimal criteria for selection were:

1. Absence of a knee-flexion contracture, a hip-flexion contracture greater than or equal to 15 degrees, or an ankle plantar-flexion contracture greater than or equal to 10 degrees.
2. Absence of any medical contraindications to exercise or walking.
3. Ability to walk 40 m with no more than “minimum” assistance and use of cane or walker.
4. Ability to understand and follow English commands.
5. First episode of a CVA and less than six months post-CVA.

**Equipment**

The equipment used in this study consisted of a Footswitch Stride Analyzer* with insole foot switches, a knee electrogoniometer,① a videotape system,② and a force walking aid.③ The Footswitch Stride Analyzer provided the quantitative measurements of gait. The instrument calculates stride data both in absolute units and as normalized scores based on data from a healthy sample of 43 men and women (J Perry, DJ Antonelli, L Barnes; unpublished report; 1981). Insoles, taped on the bottom of shoes or the soles of the feet, contained compression closing switches under the heel, the heads of the first and fifth metatarsal, and the great toe. The footswitch data were transmitted by a belt-worn battery-powered telemetry unit to an FM-FM receiver that encoded the signals into a multivoltage two-channel pattern. The signals then were simultaneously recorded on analog tape and transmitted to the Footswitch Stride Analyzer’s microprocessor for calculation of the subject’s gait characteristics (velocity, cadence, stride length, gait-cycle duration, single-limb stance time, initial and terminal double-limb stance time, swing phase time, and total stance time). The central 6 m of a 10-m walkway were bounded by photoelectric cells that demarcated on the printed record the subject’s entry into and exit from the data collection zone.

Involved step length, a variable not available from the Footswitch Stride Analyzer, was hand measured from the videoscreen. A pilot study (using stride length rather than step length) showed the mean difference between hand-measured stride length and stride length calculated from the Footswitch Stride Analyzer was less than 1 cm.

A double parallelogram electrogoniometer, driven only by joint motion in the sagittal plane, recorded knee motion in all subjects during gait. Validity of the knee electrogoniometer is 1.5 degrees with 30 degrees of flexion and 6 degrees when the knee is flexed 60 degrees.⑬ Three walking aids

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①B & L Engineering, Div of Pinasco, Inc, 9618 Santa Fe Springs Rd, Suite 8, Santa Fe Springs, CA 90670.
②Pathokinesiology Laboratory, Rancho Los Amigos Medical Center, 7601 E Imperial Hwy, Downey, CA 90242.
③JVC Model CR 6060U Videocassette Recording System, JVC Industries Co, 1011 W Artesia Blvd, Compton, CA 90220.
④Ampex FR-1300, Ampex Corp, 401 Broadway, Redwood City, CA 94063.
(four-prong cane, single-point cane, or walker) with force transducers in their weight-bearing segments were used to identify the duration of cane support and the peak force used during walking. The error in the force walking aid is 2% for the four-prong cane and walker and 8% for the single-point cane (Pathokinesiology Service, RLAMC; unpublished data; 1984). The goniometric and force walking aid output was transmitted to the analog tape recorder by an overhead cable. All data were recorded on analog tape and printed on light-sensitive paper with the foot support pattern for analysis.

**Procedure**

A pilot study was used to determine the time constraints for the patients to tolerate the entire testing procedure (training, treatment, and gait evaluation) in a single block of time. From this pilot study, the following were determined: 1) one 10-minute period was the maximum amount of time that would be allowed for teaching the pelvic patterns to the subjects, 2) treatment would consist of four sets of five repetitions each with a 1-minute rest interval between sets, and 3) the subjects would walk with the same equipment they customarily had been using.

A 15-minute clinical evaluation, assessing spasticity, proprioception, selective control, and upright control in the involved lower extremity (Appendix), was performed the day before testing. All evaluations were performed by the primary investigator with an assistant. Subjects read and signed an informed consent form written in their native language. Prior to laboratory testing, a reference distance marked on the walkway was recorded on videotape to provide a scale for measurement of step length from the video screen.

Gait measurements were made before, immediately after the PNF treatment (posttest 1), and after a 30-minute rest period (posttest 2). The subjects were asked to traverse the walkway twice, first as a familiarization session that was not recorded and then a second time for data collection.

For gait analysis in subjects wearing an ankle-foot orthosis \( n = 12 \), a pair of footswitches were taped to the bottom of the subject's shoes with the cables connected to the transmitter worn at the waist. The footswitches were taped to the soles of the feet in those subjects who did not wear an AFO \( n = 8 \). A knee electrogoniometer was attached to the involved lower extremity with the thigh cuff positioned about 15 cm above the knee and the leg cuff just below the tibial tuberosity. The zero position for the goniometer was set with the knee in complete extension by aligning the axes of the hip, knee, and ankle joints along a ruler. This reference line was recorded on analog tape before each walk. An appropriate force walking aid was substituted during the walking trials for the 19 subjects who used an assistive device.

During the treatment session, the subject was positioned on a plinth, lying on the uninvolved side. Both lower extremities were positioned in semiflexion with a pillow between the knees for comfort. The transmitter worn at the waist remained in place during treatment. The knee electrogoniometer was removed and recalibrated after treatment. The primary investigator, trained in PNF techniques, taught the subject how to perform the pelvic movement activity. Stretch stimulus, stretch reflex, manual contact, and resistance were used to teach the pelvic movement patterns to the subject. If the subject had difficulty moving the pelvis properly, appropriate techniques were used to teach the desired motions until the subject was able to perform them accurately with the guidance of the investigator's grip and resistance.

When the subject was able to perform the pattern accurately, four sets of five graded resistive movements were performed with a one-minute rest period between each set. Each movement was preceded by a quick stretch to the pattern of motion. The commands given by the investigator were to “pull up” during anterior elevation and to “push down” during posterior depression. The investigator placed her hands on the iliac crest on the involved side during anterior elevation and on the ischial tuberosity during posterior depression. During anterior elevation, the subject moved...
the involved side of the pelvis diagonally up and forward, toward the contralateral ribs (pelvic elevation and forward rotation). During posterior depression, the subject moved the involved side diagonally down and backward, away from the contralateral ribs (pelvic depression and posterior rotation).

**Data Analysis**

Footswitch records were used to identify gait-cycle events and to provide a time frame for analysis of the electrogoniometric and force cane data. Variables were grouped into three categories: 1) stride characteristics (11 variables), 2) force walking aid (6 variables), and 3) knee motion (12 variables). A total of 29 gait variables, therefore, were collected for subjects using an assistive device (n = 19), and 23 variables were collected for the subject who did not use an assistive device.

The Footswitch Stride Analyzer calculated velocity, cadence, stride length, gait-cycle duration, single-limb stance time, initial and terminal double-limb stance time, swing phase time, and total stance time. Involved-limb step length was hand measured from the video screen with the average of three consecutive steps calculated. Peak force; timing of peak force; and force at initial contact, opposite toe-off, opposite heel contact, and ipsilateral toe-off were hand measured from the force walking aid data.

Twelve gait variables were hand measured from the electrogoniometric data: peak and timing of peak knee flexion in the stance and swing phases; peak and timing of knee extension in stance; knee position at initial contact, opposite toe-off, opposite heel contact, and ipsilateral toe-off; duration of peak knee extension in stance; and total knee motion. Gait variables for knee joint motion were analyzed for deviation away from or toward normal. Normal values cited in the literature were used as the reference for comparing pretest to posttest values. For example, a subject with −5 degrees of peak knee extension in stance in pretest and +3 degrees of knee flexion in posttest was given a score of +2, assuming a normal value of 0 degrees of extension.

To determine whether overall improvement occurred in the subject's gait following treatment, standardized scores were derived (pretest minus posttest divided by one standard deviation of their mean). The standard scores were then summed and averaged for each group of variables to obtain a group standardized score. A total standardized score was assessed by averaging the subject's summed group scores. Overall improvement existed when a subject's total standardized score was greater than one standard deviation from the mean (Fig. 1). We based statistical analysis of total standardized scores on a one-tailed t test. If significance was found in either of the posttests, one-tailed t tests were used on group standardized scores at a significance level of .01, based on the Sidak equation. Those groups that showed significant gains were further analyzed using one-tailed t tests on individual variables. An analysis of variance (ANOVA) for repeated measures was used to determine differences between hand-measured variables on different days.

**Results**

No significant differences were found between hand-measured items on different days from the force walking aid, electrogoniometer, and footswitch records using an ANOVA for repeated measures.

**Gait Characteristics**

Subjects showed lower than normal values in velocity, cadence, stride length, and involved single-limb support time (21%, 48%, 40%, and 43% of normal, respectively) (Tab. 2). Gait-cycle duration (240% of normal) and double-limb support time were prolonged in the hemiplegic subjects as compared with healthy subjects (Fig. 2). Two different gait patterns were depicted from the knee motion data in the hemiplegic subjects: 1) excessive knee flexion throughout stance (n = 9) and 2) knee hyperextension in stance.

### Table 2. Stride Characteristics of Subjects Studied (N = 20)

<table>
<thead>
<tr>
<th>Stride Characteristic</th>
<th>$\bar{x}$</th>
<th>$s$</th>
<th>Range</th>
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<tbody>
<tr>
<td>Velocity (m/min)</td>
<td>17.4</td>
<td>10.8</td>
<td>(3.7–36.9)</td>
</tr>
<tr>
<td>Velocity (% normal)</td>
<td>20.5</td>
<td>12.8</td>
<td>(6.2–46.0)</td>
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<tr>
<td>Cadence (steps/min)</td>
<td>54.7</td>
<td>18.9</td>
<td>(23.4–86.2)</td>
</tr>
<tr>
<td>Cadence (% normal)</td>
<td>47.8</td>
<td>17.0</td>
<td>(19.7–76.3)</td>
</tr>
<tr>
<td>Stride (cm)</td>
<td>58.4</td>
<td>20.0</td>
<td>(28.8–97.2)</td>
</tr>
<tr>
<td>Stride (% normal)</td>
<td>39.7</td>
<td>13.6</td>
<td>(21.3–72.0)</td>
</tr>
<tr>
<td>Gait cycle (sec)</td>
<td>2.5</td>
<td>1.0</td>
<td>(1.4–5.1)</td>
</tr>
<tr>
<td>Gait cycle (% normal)</td>
<td>239.9</td>
<td>100.2</td>
<td>(130.3–507.1)</td>
</tr>
<tr>
<td>Involved SLS* (% normal)</td>
<td>43.4</td>
<td>20.6</td>
<td>(14.7–84.4)</td>
</tr>
<tr>
<td>Sound SLS (% normal)</td>
<td>64.8</td>
<td>11.2</td>
<td>(31.1–111.6)</td>
</tr>
<tr>
<td>Sound SLS (% gait cycle)</td>
<td>35.8</td>
<td>11.2</td>
<td>(17.8–55.6)</td>
</tr>
<tr>
<td>Involved I-DLS* (% gait cycle)</td>
<td>17.6</td>
<td>7.9</td>
<td>(3.4–39.9)</td>
</tr>
<tr>
<td>Involved SLS (% gait cycle)</td>
<td>23.4</td>
<td>8.9</td>
<td>(10.2–41.0)</td>
</tr>
<tr>
<td>Involved T-DLS* (% gait cycle)</td>
<td>23.4</td>
<td>13.1</td>
<td>(4.4–52.3)</td>
</tr>
<tr>
<td>Involved stance (% gait cycle)</td>
<td>64.6</td>
<td>11.0</td>
<td>(44.9–82.4)</td>
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*Single-limb support.
*Initial double-limb support.
*Terminal double-limb support.
**Fig. 2.** Durations of total gait cycles (in seconds) and the component phases (percentage of gait cycle) of stance (shaded area) and swing (unshaded area) in this study's sample of hemiplegic subjects as compared with a sample of healthy subjects. The hemiplegic subjects had a 2.5-second gait-cycle duration; in healthy subjects, it averages 1.03 seconds. (R = right side, L = left side, I = involved side, S = sound side.)

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**Fig. 3.** Mean knee motion during pretest in hemiplegic subjects displaying excessive knee flexion in stance (n = 9) or knee hyperextension in stance (n = 11) as compared with a sample of healthy subjects. Vertical lines indicate components of stance phase in hemiplegic subjects. Initial double-limb support (IDLS) and single-limb support (SLS) periods were the same for both groups. Terminal double-limb support (TDLS) period was longer for those subjects displaying knee hyperextension in stance as compared with the group with excessive knee flexion.

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Response to Treatment

Subjects' overall response to treatment in posttest 1 demonstrated a significant improvement as compared with the pretest (p < .005). Fourteen subjects showed improvement, with gains in 10 subjects greater than one standard deviation. Only 4 subjects improved greater than one standard deviation in posttest 2 compared with the pretest. Mean subject response to treatment in posttest 2, however, did not show significant improvement. When the variables were grouped into the three categories described previously, two of those categories showed significant improvements in posttest 1: force walking aid data (p < .01) and knee motion data (p < .005). Eight individual variables within those two categories showed statistically

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HEALTHY

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<table>
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<tr>
<td>R</td>
<td>61</td>
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<td>L</td>
<td>39</td>
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HEMIPLEGIC

<p>| | |</p>
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<tr>
<td>I</td>
<td>64</td>
</tr>
<tr>
<td>S</td>
<td>23</td>
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GAIT CYCLE DURATION (sec)

(n = 11). Nine subjects wearing an AFO commonly displayed knee hyperextension in stance. The durations of initial double-limb support and single-limb support periods were relatively equal in both groups. Those subjects with knee hyperextension in stance increased their terminal double-limb support period by 13% of the gait cycle (Fig. 3). Subjects from both knee motion groups displayed prolonged duration of peak knee extension (10% and 19% of the gait cycle, respectively), with extension persisting 9% of the gait cycle longer in those subjects with knee hyperextension in stance. Subjects from both knee motion groups had limited preswing-phase knee flexion at toe-off and limited peak knee flexion during the swing phase (Fig. 3).
significant improvement. Given measurement error, however, these improvements were not clinically significant. No significant gains were seen in the three categories of variables for posttest 2 when compared with the pretest.

**Improved Group**

The two patterns of knee motion found (excessive knee flexion and knee hyperextension in stance) are described separately. Only three of the nine subjects with excessive knee flexion in stance during the pretest displayed knee motion closer to a normal pattern in posttest 1. Peak knee flexion during loading response was 5 degrees less. Peak knee extension in stance increased 10 degrees, and extension at opposite heel contact increased 12 degrees. Knee flexion during the swing phase was not different between pretest and posttest 1 (Fig. 4).

Subjects in the improved group with knee hyperextension in stance during pretest (n = 7) showed a similar amount of knee flexion during limb loading, but maintained more flexion (5°) at the end of the initial double-limb support period and had less peak knee hyperextension (3°) in posttest 1. Stance time was increased 10% because of a 10% increase in single-limb support time for the posttest group. Peak knee flexion at toe-off increased 7 degrees with a 4-degree increase during the swing phase (Fig. 4).

Force on the assistive devices decreased in posttest 1 at the end of the initial double-limb support period and remained less throughout the single-limb support period (3%-4% of body weight) (Fig. 5).

**Discussion**

The gait deviations seen in our hemiplegic subjects were in agreement with studies previously reported, but the subjects in our study appeared more severely impaired based on a slower mean velocity (17 m/min vs 22 m/min to 37 m/min), longer gait-cycle duration (2.5 seconds vs 1.9 seconds to 2.25 seconds), shorter single-limb stance period (23.4% vs...
### Appendix. Hemiplegic Evaluation

<table>
<thead>
<tr>
<th>Testing Item</th>
<th>Rating Scale</th>
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<tr>
<td><strong>Proprionception (subject positioned supine, eyes closed):</strong></td>
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</table>
| 1. Hip—Therapist places hip in medial or lateral rotation, asking the subject if the foot is “in” or “out.” | 1—Scores accurately on all three trials.  
2—Misses 1 or more trials.  
3—Misses all 3 trials. |
| 2. Knee—Therapist places knee in flexion or extension, asking the subject if the leg is “bent” or “straight.” | 1—Scores accurately on all three trials.  
2—Misses 1 or more trials.  
3—Misses all 3 trials. |
| 3. Ankle—Therapist places foot in dorsiflexion or plantar flexion, asking the subject if the foot is “up” or “down.” | 1—Scores accurately on all three trials.  
2—Misses 1 or more trials.  
3—Misses all 3 trials. |

| Spasticity—Therapist determines available range of motion by passively taking the joint through ROM slowly before testing spasticity (subject positioned supine): |                                                                              |
| 1. Hip—Therapist moves hip joint passively through a “fast ROM”, noting resistance to 1) abduction and 2) adduction. | 1—No resistance felt as joint is moved passively through a fast ROM.  
2—Moderate resistance felt through fast ROM.  
3—Excessive resistance felt through fast ROM. |
| 2. Knee—Therapist moves knee joint through a fast ROM noting resistance to 1) flexion and 2) extension. | 1—No resistance felt as joint is moved passively through a fast ROM.  
2—Moderate resistance felt through fast ROM.  
3—Excessive resistance felt through fast ROM. |
| 3. Ankle—Therapist moves ankle joint through a fast ROM noting resistance to 1) flexion and 2) extension. | 1—No resistance felt as joint is moved passively through a fast ROM.  
2—Moderate resistance felt through fast ROM.  
3—Excessive resistance felt through fast ROM. |

| Selective Control (subject positioned side lying):                          |                                                                              |
| 1. Hip—Subject flexes hip while keeping knee extended; subject extends hip while knee flexed. | 1—Immediately performs maneuver accurately.  
2—Slow to respond; shows some difficulty, but able to perform maneuver accurately.  
3—Unable to perform. |
| 2. Knee—Therapist places hip and knee in flexion, asks subject to straighten knee keeping hip flexed; therapist places hip and knee in extension, asks subject to flex knee keeping hip extended. | 1—Immediately performs maneuver accurately.  
2—Slow to respond; shows some difficulty, but able to perform maneuver accurately.  
3—Unable to perform. |
| 3. Ankle—Therapist places knee in extension, asks subject to flex ankle; therapist places knee in flexion, asks subject to plantar flex ankle. | 1—Immediately performs maneuver accurately.  
2—Slow to respond; shows some difficulty, but able to perform maneuver accurately.  
3—Unable to perform. |

| Upright Control (subject is standing for all tests; two people required to administer the test): |                                                                              |
| Flexion                                                                      |                                                                              |
| 1. Hip—Therapist asks subject to bring knee toward chest; assistant gives hand support on opposite side. | 1—Actively flexes >60°.  
2—Actively flexes 30°–60°.  
3—No motion or actively flexes <30°. |
| 2. Knee—Therapist asks subject to bring knee toward chest; assistant gives hand support on opposite side. | 1—Actively flexes >60°.  
2—Actively flexes 30°–60°.  
3—No motion or actively flexes <30°. |
| 3. Ankle—Therapist asks subject to bring knee and foot toward chest; assistant gives hand support on opposite side. | 1—Actively dorsiflexes to a right angle or greater.  
2—No motion or actively dorsiflexes <90°. |
| Extension                                                                    |                                                                              |
| 1. Hip—Therapist provides hand support on opposite side; assistant provides ankle and knee support; therapist asks subject to lift uninvolved leg. | 1—Maintains trunk erect on hip.  
2—Unable to maintain trunk erect but able to stop forward trunk motion; wobbles back and forth; hyperextends trunk on hip.  
3—Uncontrolled trunk flexion on hip. |
Testing Item | Rating Scale
--- | ---
2. Knee—Therapist positions knees at 30°; assistant provides hand support on opposite side; therapist asks subject to lift uninvolved leg and to straighten knee. | 1—Supports body weight on flexed knee and able to straighten knee on request. 2—Supports body weight on flexed knee without heel rise or increased flexion. 3—Unable to maintain body weight on flexed knee. 4—Excessive tone; unable to position knee flexion. |
3. Ankle—Therapist prevents knee hyperextension of involved leg; assistant provides hand support; therapist asks subject to lift uninvolved leg and to go up on toes. | 1—Maintains knee at neutral and lifts heel off floor. 2—Maintains knee at neutral. 3—Unable to maintain knee at neutral. 4—Excessive equinus or varus; unable to maintain plantigrade platform. |

**Scoring System**

<table>
<thead>
<tr>
<th>Proprioception:</th>
<th>Spasticity:</th>
</tr>
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<tbody>
<tr>
<td>1 = Intact</td>
<td>2 = None</td>
</tr>
<tr>
<td>2 = Impaired</td>
<td>3 = Minimum</td>
</tr>
<tr>
<td>3 = Absent</td>
<td>4 = Moderate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Selective Control:</th>
<th>Upright Control (Flexion and Extension):</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 = Normal</td>
<td>1 = Strong</td>
</tr>
<tr>
<td>3 = Minimum</td>
<td>2 = Moderate</td>
</tr>
<tr>
<td>4 = Moderate</td>
<td>3, 4 = Weak</td>
</tr>
<tr>
<td>5, 6 = Severe</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

*Fast ROM* is defined as the quickest motion the therapist can use passively in the subject's available ROM.

ROM measured objectively by primary investigator in all tests. (Upright control test adapted from Montgomery J, Gillis KM, Weinstein C, *Physical Therapy Management of Patients with Hemiplegia Secondary to Cerebrovascular Accident*, Downey, CA, Professional Staff Association of Rancho Los Amigos Medical Center, Inc, 1979.)

45%24), and shorter duration post-CVA (2 months vs 3 months20 to 13 years24). Lehmann's sample of 7 hemiplegic patients demonstrated excessive knee flexion during stance (range = 4°–17°; mean velocity = 27.8 m/min).24 Nine of our subjects demonstrated excessive knee flexion during stance; however, greater knee flexion values were observed in our study (range = 10°–22°; mean velocity = 19 m/min) than in Lehmann's study.24

Basically, the major improvements seen immediately posttreatment were in stance stability and limb advancement in the involved limb. Further evidence of the improved stance stability were decreased force on assistive device at the end of initial double-limb support, mid-stance, and beginning of terminal stance; improved knee motion during initial double-limb support; and improved peak and duration of knee extension in stance. Evidence of improved limb advancement was demonstrated in a longer step length and more knee flexion in the swing phase. Although those gait variables showed statistically significant improvements in posttest 1, most motion differences were less than 5 degrees and may not be clinically relevant.

Studies have shown that many gait variables, including time-distance variables and angular limb motion, are velocity dependent.26,27 The treatment had no effect on velocity; therefore, we were not surprised to see no change in the subjects' stride characteristics. The improvements in knee motion and weight on force aid, therefore, cannot be explained by changes in velocity.

The changes in knee motion may have occurred secondary to improvements in pelvic and hip motion. Ten subjects were also analyzed using automated motion analysis; however, only 4 of those subjects were also in the improved group. The results of the study, therefore, were inconclusive. Major gait deviations of the pelvis and hip observed in the hemiplegic subjects studied were excessive pelvic anterior tilt occurring throughout the gait cycle and limited hip flexion in the swing phase and at initial contact, which persisted throughout the single-limb support period. Both hip and pelvic position at initial contact showed a mean increase of 5 degrees in the four subjects who were also in the improved group. At the hip, this improvement remained throughout initial double-limb support. Subjects increased pelvic motion (toward posterior tilt) 5 degrees during single-limb support and during the swing phase in posttest 1.

Improvements observed may be due to spontaneous recovery; however, the time lapse from pretest to posttest was a maximum of 45 to 60 minutes. Second, a comparison of two gait trials on 17 hemiplegic patients (P. R. Trueblood, unpublished pilot study, November 1984) was analyzed to determine the normal variation between gait trials. No significant differences in temporal characteristics or knee electrogoniometric data were found.
One explanation for the lack of carry-over demonstrated in this study may be subject fatigue. Overall, eight subjects performed worse in posttest 2 than in the pretest or in posttest 1, with three having a mean score less than one standard deviation. The entire test required about 1.5 hours to complete. Although the actual treatment was only 15 minutes in duration, it was questionable whether some subjects could tolerate the entire testing process. Increasing the number of treatment sessions over a period of time may assist in determining an optimum treatment with carry-over from this technique.

The clinical evaluation used in this study did not prove to be useful in predicting the subjects’ response to treatment. Several limitations are present in the scoring process of the evaluation. For example, the evaluation was not sufficiently sensitive to differentiate among subjects whose primary problems were patterned movements, involved lower extremity weakness, or lack of upright balance. Further studies may benefit from examination of individual groups of patients based on type and severity of involvement for purposes of comparison.

We were unable to determine why 50% of subjects improved and 50% of subjects did not improve in posttest 1 based on the data from this study. Overall, the subjects in the improved group tended to be more involved than those in the unimproved group, based on a slightly slower pretest velocity and cadence, longer gait-cycle duration, shorter involved single-limb stance time, more force on assistive device, and higher total evaluation scores. This involvement was more evident when the improved group included 4 additional subjects who gained in posttest 1 but did not show statistically significant improvement. Furthermore, when we compared the 14 subjects who improved with the 6 who did not, those subjects in the unimproved group demonstrated selective control at the hip; overall, only 3 of the 6 subjects demonstrated lack of selective control in the knee and ankle on the involved side. Based on subjective information, the subjects who learned the exercise easily did not make substantial gains in their gait after treatment. Perhaps, they already had selective control at the pelvis and therefore did not benefit from the treatment, or their total time of treatment was shorter because they did not require a lengthy learning session. There may be a trend for patients with patterned movements to benefit more from this treatment technique, as compared with those who demonstrate selective movements proximally.

Summary

Gait in 20 hemiplegic subjects was analyzed before, immediately after, and 30 minutes after a treatment based on the PNF philosophy of resisted pelvic exercises. Based on the findings from this study, a 15-minute PNF-based pelvic exercise regimen improved eight variables studied immediately after treatment, but did not demonstrate carry-over 30 minutes after treatment in the hemiplegic patient. We found no significant differences in the pretest characteristics between the improved and unimproved groups. More research is needed because a potential for a positive response to this type of treatment exists, as indicated by the results of this study.

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