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Using an Isokinetic Exercise Machine to Improve the Gait Pattern in a Hemiplegic Patient

A Case Report

PATRICIA ANN WILDER
and JOHN SYKES

Key Words: Hemiplegia; Gait; Exercise, isokinetic.

This paper presents the case report of a hemiplegic patient who was treated in a therapeutic exercise program using a Kinetron* bilateral lower extremity isokinetic exercise machine. The therapist wanted to identify the benefits this machine might have in improving the gait pattern of a hemiplegic patient. Specifically, he wanted to determine if the machine could inhibit a strong extensor synergy pattern in the involved lower extremity of a hemiplegic patient by first increasing the ability of the patient to initiate active and controlled hip flexion in the same extremity. The authors expected that if the extensor thrust was reduced, then sufficient, voluntary hip flexion would be possible, which would, in turn, promote a more normal gait pattern for ambulation.

Therapists who treat hemiplegic patients are familiar with the patient who uses a total extension synergy pattern with hyperextension at the knee during the weight-bearing phase of gait on the involved extremity. He then hikes the pelvis and circumducts the same extremity during the swing phase of gait because of inability to initiate sufficient and quick enough active hip flexion to move the leg as needed. Inadequate heel strike and foot drop are also evident in many of these patients. This means the mass synergy pattern of extension controls the movement of the involved extremity. The patient therefore develops a functional but abnormal gait pattern that becomes easier with constant use and may eventually create abnormal stresses. These stresses could produce irreversible structural changes in joints and tendons, specifically in the knee joint and the quadriceps tendon on the involved side.

PATIENT DATA

The patient in this study, M.B., was a 66-year-old man, who six months before had undergone a left cerebrovascular accident that resulted in spastic right hemiplegia. The results of the initial neurological examination of this patient are found in Table 1. A gait evaluation of M.B. using a cane was done according to Boenig1 (Tab. 2). M.B. displayed a strong extensor synergy pattern in the involved right lower extremity. He used the total extension pattern with hyperextension at the knee for weight bearing on the involved side. He was unable to initiate active hip flexion with the right extremity at the end of stance phase and therefore used a sequence of movements consisting of hiking the pelvis and circumducting the leg to move the extremity through swing phase and on to heel strike. Increased plantar flexion produced at heel strike by the extension synergy added to the abnormal pattern. M.B. used a quad cane and a plastic ankle-foot orthosis for ambulation.

M.B. had received no outpatient physical therapy during the four months before the initial examination. He had, however, received daily physical therapy and occupational therapy while hospitalized for four weeks after the initial accident. The treatments generally consisted of a traditional exercise program that emphasized range-of-motion exercises for the involved right side and strengthening exercises for the uninvolved left side. Gait-training procedures with a quad cane and a plastic ankle-foot orthosis were also practiced. Occupational therapy consisted of teaching M.B. functional activities of daily living, such as feeding and dressing. When he was discharged from the hospital, he was using a quad cane and a plastic ankle-foot orthosis to aid with independent ambulation. M.B. could walk independently in his home for short distances; however, he did not feel safe walking outside without stand-by assistance. His endurance for walking was very limited. M.B. was determined to get better and came to us seeking assistance to

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* Cybex Division of Lumex, Inc, 2100 Smithtown Ave, Ronkonkoma, NY 11779.
### TABLE 1
Examination Results of Lower Extremities

<table>
<thead>
<tr>
<th>Tests</th>
<th>Preexamination</th>
<th>Postexamination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Side (involved)</td>
<td>Left Side (uninvolved)</td>
</tr>
<tr>
<td>Sensation</td>
<td>Intact</td>
<td>Intact</td>
</tr>
<tr>
<td>DTRs</td>
<td>Biceps +4</td>
<td>+2</td>
</tr>
<tr>
<td></td>
<td>Quadriceps +4</td>
<td>+2</td>
</tr>
<tr>
<td></td>
<td>Achilles +4</td>
<td>+2</td>
</tr>
<tr>
<td>ROM</td>
<td>Complete when done passively</td>
<td>Complete and done actively</td>
</tr>
<tr>
<td>Manual muscle test*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion = F</td>
<td>G</td>
<td>G-</td>
</tr>
<tr>
<td>Extension = T</td>
<td>G</td>
<td>P</td>
</tr>
<tr>
<td>Adduction = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Abduction = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Int. Rotation = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Ext. Rotation = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Knee:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Extension = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Ankle:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantar flexion = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Dorsiflexion = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Inversion = T</td>
<td>G</td>
<td>T</td>
</tr>
<tr>
<td>Eversion = T</td>
<td>G</td>
<td>T</td>
</tr>
</tbody>
</table>

* Muscle test was graded using the standard format of Normal (N), Good (G), Fair (F), Poor (P), and Trace (T). The grading was subjective because the patient had difficulty isolating specific muscles as a result of spasticity.

Improve his gait pattern and his endurance in ambulation.

**UNIQUE FEATURES OF THE PROBLEM**

The isokinetic machine used for his treatment was chosen for several reasons. The physical design of the machine seemed to be beneficial for this patient because the machine would allow the patient to exercise his lower extremities in several different positions. M.B. could start an exercise program in a sitting posture and gradually work to a more upright or standing posture. The therapist believed that exercising in the sitting posture could possibly inhibit some of the strong extensor-thrust pattern, most evident when the patient was in an upright or standing position, and also would help to facilitate active hip flexion in the involved extremity.

Another reason the isokinetic machine was chosen was because the therapist believed the machine capable of developing the patient’s muscular strength, power, coordination, and endurance. Strength, the ability to produce force, can be developed in the muscles of the lower extremity because the machine can provide progressive resistance to the movements of flexion and extension needed for walking. With an isokinetic machine, the amount of resistance depends on the patient’s volitional effort exerted against a preset speed. Muscle power, the ability to produce a certain amount of force in a given amount of time, can be developed because of this machine’s ability to accommodate the resistance provided at a preset speed. This allows the patient to move at a slow speed and thereby produce a greater amount of force than he may be able to produce when working at a fast speed. When exercising at a fast speed, the patient would have to be able to produce the movement quickly while maintaining the designated force. That is, the patient may have enough strength when working at a slow speed to produce a certain force but may not have enough strength to produce that same force when working at a faster speed: he has strength but not power. Both strength and power are needed during normal ambulation because specific muscles must produce a specific force in a specific amount of time. The isokinetic exercise machine can develop not only a patient’s strength but also a patient’s muscle power if the exercise program is designed and carried out appropriately.

A patient can develop coordination of movements by using this machine, because he can perform bilateral reciprocal movements while working on it. Bilateral reciprocal movements have been shown to be beneficial for hemiplegic patients. In addition, endurance can be increased by increasing the amount of time the patient spends exercising on the machine at any one time.

Another reason the therapists were interested in using the machine as the major component of a
A rehabilitation program for a hemiplegic patient was that a review of the literature revealed no long-term studies indicating whether such a machine might benefit this type of patient. Studies revealing the positive effects of the machine were conducted on patients with musculoskeletal and peripheral neuromuscular problems, such as amputations.\textsuperscript{3, 4}

The objective of this exercise program was to determine if the isokinetic exercise machine could improve the gait pattern of a hemiplegic patient. This would be done by increasing active hip flexion and inhibiting the extensor synergy pattern of the involved extremity and at the same time increasing the strength, power, coordination, and endurance of the lower extremities.

**THE PHYSICAL THERAPY PLAN**

The patient was scheduled for exercise sessions three times a week for a total of 27 sessions. During each session, the patient exercised for 30 minutes—two 15-minute periods of exercise with a 5-minute break in-between. The patient's pulse was taken before the first 15-minute period and at the beginning and end of each rest period to obtain some information of how hard the patient was working and whether more time was needed for resting before starting the second 15-minute exercise period. If the pulse rate was greater than 20 beats above pre-exercise level after 5 minutes of rest, then the patient would not continue exercising until the pulse rate was within this range. Also during the rest period, the necessary adjustments were made on the machine for the second part of the exercise program.

The first 15-minute period of a session was directed at working to inhibit the strong extension pattern and increase active hip flexion in the involved extremity. The procedure for this was as follows:

1. The machine was adjusted so that the uninvolved lower extremity did not participate in the exercise (Fig. 1).
2. The involved lower extremity was secured to the foot plate with a Velcro strap (Fig. 1).
3. The seat and actuator heights were adjusted so that the patient was positioned in about 45 degrees of hip flexion, about 80 degrees of knee flexion, and less than 10 degrees of ankle dorsiflexion. This position did not allow terminal hip or knee extension during exercise (Fig. 1).
4. The speed was set at 10 so that the patient could actively initiate hip flexion and try to obtain between 50 and 60 degrees of active hip flexion. There have been no specific speeds determined by the manufacturer for initiating flexion.\textsuperscript{5}
5. If the patient had problems initiating flexion, the machine was counterbalanced; that is, weight was added to the ipsilateral arm of the machine to assist in hip flexion.
6. The patient was instructed to pull the foot pedal up with the involved lower extremity and to maintain a predetermined baseline force on the gauge.

### TABLE 2

**Gait Variables for Patient with Right Hemiplegia (Using a Cane)**

<table>
<thead>
<tr>
<th>Evaluation Number</th>
<th>Cadence (steps/min)</th>
<th>Velocity (m/min)</th>
<th>Step Width (cm)</th>
<th>Stride Length (cm)</th>
<th>Foot Angle (°)</th>
<th>Step Length&lt;sub&gt;a&lt;/sub&gt; Left (cm)</th>
<th>Step Length&lt;sub&gt;b&lt;/sub&gt; Right (cm)</th>
<th>Ratio of Time Spent Weight Bearing&lt;sup&gt;c&lt;/sup&gt; (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46.0</td>
<td>12.1</td>
<td>toe-toe 23.3</td>
<td>40.8</td>
<td>L-16 R-25</td>
<td>27.9</td>
<td>13.8</td>
<td>.70</td>
</tr>
<tr>
<td>2</td>
<td>49.2</td>
<td>15.4</td>
<td>heel-heel 12.3</td>
<td>47.3</td>
<td>L-18.2 R-27.2</td>
<td>31.9</td>
<td>17.6</td>
<td>.79</td>
</tr>
<tr>
<td>3</td>
<td>52.7</td>
<td>15.5</td>
<td>toe-toe 26.0</td>
<td>51.0</td>
<td>L-18 R-16.3</td>
<td>26.0</td>
<td>24.2</td>
<td>.89</td>
</tr>
<tr>
<td>4</td>
<td>45.9</td>
<td>14.0</td>
<td>heel-heel 13.8</td>
<td>47.0</td>
<td>L-21.1 R-18.2</td>
<td>22.3</td>
<td>26.2</td>
<td>.97</td>
</tr>
</tbody>
</table>

<sup>a</sup> The distance from heel strike to heel strike of the ipsilateral foot.

<sup>b</sup> The distance from one heel strike to the heel strike of the contralateral foot.

<sup>c</sup> The ratio of time spent from heel strike to toe off of one extremity compared with the other extremity, left:right.
The manufacturer has set no specific guidelines for force development with flexion.

The second part of the exercise program was directed at obtaining controlled extension in the involved extremity. The following adjustments were necessary for this part of the exercise program: 1) The patient was positioned with the involved extremity in 80 to 90 degrees of hip flexion, 80 degrees of knee flexion, and less than 20 degrees of ankle dorsiflexion. This positioning was to inhibit the extensor synergy in the involved right lower extremity. 2) The speed was adjusted so that the patient had to push quickly into hip and knee extension and still maintain 80 to 100 psi. The patient was instructed to push his foot down.

As the patient progressed in his ability to initiate hip and knee flexion and to control hip and knee extension, the following adjustments were made on the machine:
1) The amount of hip and knee extension was increased by raising the height of the seat (Fig. 2).
2) The speed of the machine was increased, and the patient had to continue to maintain about 80 to 100 psi, thereby attempting to increase his muscle power.

**TREATMENT RESULTS**

The patient was striving to produce active hip and knee flexion and extension movements of the involved extremity at a speed of 7 and at the same time maintain a force of between 80 and 100 psi and not produce an extensor-thrust reflex pattern during the extension movements. The manufacturers of Kinetron have established these guidelines for developing a normal gait pattern in patients with musculoskeletal problems. In this treatment program, the patient increased his speed from 3 to 4 for the extension exercises during the nine-week exercise program. There was no change in the setting of speed for the flexion part of the exercise program.

The gait evaluation performed at the end of the nine-week exercise program revealed that certain changes had occurred in the patient's gait pattern. Table 2 shows that M.B. had a slight increase in the variables of velocity and stride length. Step length on the involved right side increased, which may have accounted for the increase in the overall stride length. The ratio of weight-bearing time (left extremity:right extremity) approached one.

The final neurological examination revealed no significant changes in neuromuscular abilities, for example, in active range of motion. Subjective data from M.B. taken at the end of the exercise program revealed that he believed he was walking with less effort and that he had developed more confidence in his walking abilities. M.B. continued to use a quad cane for ambulation throughout the exercise program.

**DISCUSSION**

Although generalizations for an entire population cannot be made based on a single case report, some interesting findings do emerge. We hope this report will encourage more therapists to use this machine as part of a total exercise program for hemiplegic patients to document more adequately the usefulness and the appropriateness of this machine for this population.
Objective measures for assessing whether the extension synergy was inhibited and volitional flexion facilitated remain to be identified. We think that the measure of step length and stride length possibly could be used to indicate a decrease in the abnormal synergy and an increase in the desired movement but realize that a more sophisticated study would be necessary to substantiate these ideas. If our ideas are substantiated, then the isokinetic exercise machine could be used to produce a more normal gait pattern in patients that exhibit abnormal synergy patterns during ambulation.

This program did make some observable and possibly significant changes in M.B.'s gait pattern. The increases in stride length and step length for the involved extremity and the .97 ratio of time spent in weight bearing were indicators that a more normal gait pattern had been obtained by the patient. We observed that during walking, this patient did not demonstrate an increase in hiking of the pelvis or circumduction of the hip but had increased his ability to initiate and perform active hip flexion through a set range. We believe the exercise machine had some influence on producing these desired results.

As stated earlier in this manuscript, the manufacturers of Kinetron have established guidelines for speed settings and subsequent force production for developing a normal gait pattern. We do not know how these guidelines were established. If the samples used when establishing these guidelines were subjects ranging in age from 20 to 40 with no physical problems, the guidelines may not be appropriate for the healthy geriatric individual. M.B.'s maximum power before the stroke was unknown. Therefore, it is difficult to determine whether his increase in power ability (from a speed setting of 3 to 4) during the exercise program was significant. Future research with this machine using different sample populations may help to clarify these questions.

One positive characteristic of the exercise machine that we did not fully realize initially is the potential for this machine to be used to facilitate the integration of movement of both sides of the body. Because the unit is a bilateral exercise machine, it should be useful for developing coordination and integration of movement of the two sides of the body. Perhaps some of the improvement that M.B. demonstrated in his ambulation skills can be attributed to the fact that his exercise program included the integration of the involved extremity in a functional activity.

In summary, we believe that a machine such as the Kinetron with the component of accommodating resistance can be effective in changing certain neurological factors influencing a gait pattern. From our experience with this case, we believe the benefits to the patient from using this type of machine might be more significant if it is used in conjunction with neurophysiological techniques of exercise (eg, proprioceptive neuromuscular facilitation, Bobath approach). This unit should probably not be used as the single component of an exercise program.

REFERENCES

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