Effects of Isokinetic Training on the Rate of Movement During Ambulation in Hemiparetic Patients

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The purpose of this study was to determine the effects of isokinetic training on the rate of movement during ambulation in hemiparetic patients. Ten male and 10 female subjects, aged 40 to 75 years, participated in the study. The 20 hemiparetic subjects were assigned randomly to either a control group or an experimental group. All of the subjects participated in a conventional therapeutic exercise program and gait training. The experimental group also received isokinetic training on the Kinetron® exercise machine as part of their program. Functional ambulation profile tests were administered to each subject before and after the five-week experimental period. All of the subjects showed improvement in the rate of ambulation and in overall ambulation performance. The differences in ambulation times and functional ambulation profile scores between the two groups were shown to be insignificant.

Key Words: Exercise therapy, Gait, Hemiplegia.

Physical therapists use a variety of exercise theories and procedures to facilitate or inhibit motor responses in the extremities of hemiparetic patients. Three major modes of training that physical therapists currently use are isometric, isotonic, and isokinetic exercises.

In isometric exercise, relatively large resistance permits the muscle to develop loading, but maximal tension is achieved only at one point in the range of motion. The clinical value of isometric exercise is limited because the demand it places on the neuromuscular system does not always parallel an individual’s needs.

During isotonic exercise, resistance to the body segment remains constant throughout the entire ROM. The tension demand placed on a muscle is maximal only during a small portion of its ROM, causing the total work done to be less than maximum capacity. The clinical value of isotonic exercise, therefore, is limited by its inability to impose maximal tension and work demands on a muscle throughout its full range of action.

Isokinetic exercise is different from the other modes. If maximal muscular force is applied to the lever arm throughout the ROM and the speed of movement of the lever arm remains constant, the muscle contraction is termed isokinetic. An isokinetic exercise machine provides resistance at a fixed speed in direct proportion to the amount of muscle force exerted by the subject. Resistance accommodates the varying force at the skeletal lever, and the muscle is able to maintain a state of maximal contraction through its full ROM.

In isotonic and isometric exercises, the speed of the body segment is not specifically controlled. In isotonic exercise, the speed of the body segment varies with the amount of muscular force exerted because the resistance is constant. Isometric exercise may be considered as a technique of controlling the speed at zero. During isokinetic exercise, the speed of the body segment remains constant. Increased muscular force produces increased resistance of the mechanical device. An isokinetic exercise device provides a suitable mechanical means of maintaining the maximal muscular force of a body segment throughout a ROM without permitting acceleration.

Initial studies conducted by Thistle et al., Smith and Melton, and Moffroid et al. established that isokinetic exercise increased performance levels more efficiently than other exercise modes. Experiments that followed these earlier studies investigated specific training methods using isokinetic exercise equipment.

Pipes and Wilmore compared isotonic and isokinetic exercise training procedures and the differences between low- and high-speed isokinetic exercise training. Their results paralleled those obtained by Moffroid and Whipple. These investigations showed that low-speed isokinetic exercise training produced greater increases in muscular force only at low speeds, and high-speed isokinetic exercise produced increases in muscular force at all speeds of muscle contraction at and below the training speed.

Smith and Melton compared the Cybex® and Nautilus® exercise machines for training healthy individuals. The results of their study differed from those obtained by Pipes and Wilmore and Moffroid and Whipple. Smith and Melton showed that high-speed isokinetic exercise training produced increases in muscular force only at high speeds, and low-speed isokinetic exercise training produced increases in muscular force at both low and high speeds.

The Cybex® was used for testing and training in most of the studies that were conducted to assess the effects of isokinetic exercise. Another isokinetic exercise machine used by

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physical therapists is the Kinetron® as a training device for a hemiplegic patient. The machine was set at a high speed of 10 and the patient was required to maintain a pressure of 80 to 100 psi throughout the training program. After 27 sessions, the patient exhibited an increase in step and stride length of the involved extremity, and gait deviations were minimized. The Kinetron® proved to be an effective training device for changing the gait pattern of a spastic right hemiplegic patient.

Through these studies and others, isokinetic exercise has been shown to increase performance levels more efficiently than other exercise modes. Most of these investigations involved the use of healthy subjects; however, studies of the effects of isokinetic exercise training on patients with a neuromuscular disorder are needed.

The purpose of my study was to determine the effects of isokinetic exercise training on the rate of movement during ambulation in hemiparetic patients. Evidence has shown that high-speed isokinetic exercise training improves performance at all speeds of muscular contraction at and below the training speed. I hoped to demonstrate that high-speed isokinetic exercise training would produce a quicker reaction of muscle groups in the lower extremities, therefore, improving the rate of ambulation in hemiparetic patients. I expected the experimental group to show significant decreases in ambulation time and increases in the overall functional ambulation profile scores when compared with the control group after completion of the five-week training program using the Kinetron®.

METHOD

Subjects

Twenty hemiparetic patients between the ages of 40 and 75 years participated in the study. Each patient exhibited right or left hemiparesis as a result of a cerebrovascular accident (CVA) three to six months before the study. The cause of the CVA in the majority of the subjects was thrombosis of the middle cerebral artery.

The subjects were assigned randomly to either the control or experimental group, with an equal number of right and left hemiparetic patients in each group. The patients were required to read and sign a consent form before participating in the study. The experimental group consisted of one female and four male left hemiparetic patients and three female and two male right hemiparetic patients. The control group consisted of three female and two male left hemiparetic patients and three female and two male right hemiparetic patients. All of the subjects displayed upper and lower extremity motor dysfunction. Some of the patients demonstrated more sensory deficits than others, and some had mild forms of expressive or receptive aphasia. According to Brunstrom's seven recovery stages, the control group subjects started with the affected lower extremity in stages two and three, and the experimental group subjects started in stages two, three, and four.

Procedures

Three computerized functional ambulation profile (FAP) tests were administered to each patient before and after the five-week experimental period. The FAP is a valid, reliable, and objective method of assessing specific components of ambulation and overall performance of locomotion. The computerized system was designed and developed by J. Tucker and by A. J. Nelson and currently is used at our rehabilitation facility. The development of the computerized FAP system has not been documented. The computer records specific components of locomotion that include ambulation time, speed, number of steps, cadence, step time, cycle time, step length, stride length, and stride-extremity ratio. Each patient was required to complete the three FAP tests during one testing session. The first test was considered a preliminary trial test and was not used in the final data analysis. The average FAP scores of the last two tests were computed for all of the patients.

The experimental and control groups were administered a therapeutic exercise program that consisted of techniques based on neurophysiological and developmental theories. Eight physical therapists used the same specific therapeutic exercise procedures to facilitate or inhibit motor responses in the hemiparetic patients. They were given the specific instructions in the therapeutic exercise procedures to perform during the sessions according to the methods described by Knott and Voss. Each therapist treated at least one patient from each group, and the therapists were responsible primarily for their assigned patients throughout the study.

All of the patients were seen in the physical therapy department twice a day for one-hour treatment sessions for five consecutive days each week. The therapeutic exercise program and gait training were administered to the control group during both treatment sessions. During the first week of the training period, the experimental group received 1 hour and 50 minutes of therapeutic exercise and gait training with their assigned therapist and then independently exercised for 10 minutes using the Kinetron®. An additional five minutes of exercise using the Kinetron® was performed each week until the fifth week of the training program. During the fifth week, the patients in the experimental group exercised for 30 minutes using the Kinetron® and then received 1 hour and 30 minutes of therapeutic exercise and gait training. This particular progression of exercise using the Kinetron® was chosen because of its potential effects on the patient's cardiovascular system.

During the treatment sessions using the Kinetron®, each patient in the experimental group sat on the machine in a semi-sitting position with one lower extremity stabilized at 30 degrees of hip flexion and 20 degrees of knee flexion. The patients performed 25 repetitions of bilateral lower extremity exercise, rested one minute, and then repeated the procedure for the total time interval selected for that particular week of the training program. One repetition on the Kinetron® was considered to be one heel strike to heel strike on the same lower extremity. The patients were required to maintain a pressure of 50 to 100 psi on the gauges set in front of them while they performed the exercises.

The Kinetron® was set at one speed for each subject throughout the five-week period. The speed was determined for each subject using the following procedure. One lower extremity was stabilized at 30 degrees of hip flexion and 20 degrees of knee flexion. The patient was instructed to complete one repetition on the Kinetron®. The time that elapsed

‡ Kinetron, Lumex, Inc, 2100 Smithtown Ave, Ronkonkoma, NY 11779.
for the patient to perform one repetition was recorded using a stopwatch to approximate the cycle time for that individual. The trial cycle times varied among the subjects; therefore, the speed settings on the Kinetron® ranged from 6 to 10 during the training program. The speed of the machine then was set for each daily treatment session according to the speed setting that was established during the trial.

Data Analysis

The differences in the overall FAP scores between the two groups were compared using the two-way analysis of variance (ANOVA) factorial design with repeated measures on one factor. Pretest values were compared using an unpaired t-test. The same procedure was used to compare ambulation times between the groups. The analyses also included the comparison of differences within the groups for time and interaction effects.

RESULTS

All of the subjects showed improvement in overall ambulation performance as measured by FAP scores and the rate of ambulation. Table 1 shows the results of the ANOVA for FAP scores. The differences in the FAP scores between the experimental and control groups were found to be insignificant. The differences in the FAP scores over time within each group of patients showed significant results (p < .0001). The effect within each group was the change in performance observed over time and was independent of the type of treatment that the patients received.

The two-way ANOVA in Table 2 shows no significant difference for ambulation time between the experimental and control groups. The differences in ambulation time within each group of patients were statistically significant (p < .0001).

Table 3 illustrates the means and standard deviations for pretest and posttest values of FAP scores and ambulation times of both groups. The mean of the FAP scores was lower and the mean of ambulation times was higher in the control group when compared with the experimental group before treatment was administered. The difference between mean pretest values of the two groups was not significant at the .05 level for ambulation performance and ambulation time. Both groups showed a similar mean improvement in overall ambulation performance and similar mean decreases in ambulation time.

DISCUSSION

The patients in this study progressed through Brunnstrom’s recovery stages at different rates. All of the patients improved in lower extremity motor function. The patients began in categories two, three, and four and progressed to the next stage of recovery after the five-week program. No difference was observed in the changes between the experimental and control groups after the training period.

An observation that was made during the experiment related to the motivation that was demonstrated by the patients using the isokinetic exercise device. The patients in the experimental group began the Kinetron training program with enthusiasm. As the patients progressed through the five-week program, a decrease in motivation and enthusiasm was evident. Some of these patients seemed to prefer the individual attention and manual exercises provided by their assigned therapist. The results obtained in the experiment may have been affected by this psychological factor.

Studies that have been conducted using isokinetic exercise equipment have shown that isokinetic exercise increased performance levels more efficiently than other exercise modes. Thistle and his associates compared the results of isokinetic exercise using the Cybex® scored higher than the other groups in total work output and peak force generated.

In comparison with past studies, my investigation did not show a difference in results between isokinetic exercise training and other exercise modes. Each control group patient showed an improvement in the rate of ambulation after completing the therapeutic exercise program. The experimental and control groups showed no significant differences in ambulation performance after the five-week program. Evidence also exists that isokinetic exercise training at higher speeds increased performance more efficiently than isokinetic exercise training at slower speeds. The study con-
ducted by Barnes showed that muscular deficiencies occurring at specific contractile speeds might be identified and corrected by having the patient exercise isokinetically at the speeds at which the differences occurred. To improve performance of patients with a neuromuscular disorder in my investigation, I set the isokinetic exercise device at speeds of 6 through 10, demanding muscular contractions at higher speeds where muscular deficiencies existed. Each patient in the experimental group showed significant improvement in the rate of ambulation after high-speed isokinetic exercise training. These results confirm the findings obtained by Barnes.

Minimal research has been undertaken using the Kinetron® as a training device. Many of the past isokinetic exercise studies were conducted on healthy subjects using the Cybex® for testing and training. Further study is recommended using the Kinetron® in different training regimens for patients with various types of neuromuscular disorders. Future research also may compare the performance levels of hemiparetic patients in various stages of recovery. Isokinetic exercise training may prove to be more beneficial in the later stages of recovery in hemiparetic patients. The performance levels of left and right hemiparetic patients also may be compared.

CONCLUSION

The 20 hemiparetic patients who participated in the study showed an overall improvement in ambulation performance. The experimental and control groups exhibited significant improvement in ambulation time. The experimental group began the therapeutic exercise program with faster ambulation times than the control group, but both groups showed equal progress after the five-week training period. The difference in ambulation time between the two groups was shown to be insignificant. No significant difference was found in the rate of ambulation between the group that participated in an isokinetic exercise training program and the group that participated in a conventional therapeutic exercise program.

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REFERENCES