Knee Extension Torque During Repeated Knee Extension-Flexion Reversals and Separated Knee Extension-Flexion Dyads

RICHARD W. BOHANNON

I measured the knee extension torque, produced by eight hemiparetic patients during repeated knee extension-flexion reversals and during separated knee extension-flexion dyads, to determine the effect of “reversal of antagonists” on knee extension torque. The hemiparesis in these eight patients was secondary to intracranial lesions. I tested their involved lower extremity on an isokinetic dynamometer at 60°/sec. Using a sequential medical-trials design, I found knee extension torque to be significantly greater during repeated knee extension-flexion reversals than during separated knee extension-flexion dyads (p < .05). I, therefore, concluded that reversal of antagonists may facilitate knee extension torque production in the type of patients tested, under the specific conditions of their testing.

Key Words: Hemiplegia, Knee, Muscles, Physical therapy.

Among the facilitation techniques espoused by Knott and Voss is that of “reversal of antagonists.” According to these experts in therapeutic exercise, the stimulation effect of the technique that incorporates the resisted contraction of an antagonist before contraction of an agonist “is readily demonstrated in the normal subject.” Although their statement has a neurophysiological basis, the statement has not, as far as I am aware, been experimentally verified. Contrary to the claim by Knott and Voss, my associates and I did not find knee extension torque enhanced in healthy subjects by the contraction of the knee flexor muscles before the contraction of the quadriceps femoris muscles. Gibson and I did, however, find that a quadriceps femoris muscle stretch may have a limited early facilitatory effect on subsequent knee extension torque production in healthy subjects. We suggested, therefore, that muscle stretch may be partly responsible for the apparent effects of reversal of antagonists. Although these two studies comprise a preliminary investigation into the claimed effects of reversal of antagonists, the studies are both limited because my associates and I tested healthy subjects.

If clinicians are to base their practice on subjective research findings, rather than on less sound foundations, the validity of techniques such as reversal of antagonists must be confirmed on patients. The purpose of this investigation was to test the effect of reversal of antagonists on paretic quadriceps femoris muscles by comparing the knee extension torque produced during repeated knee extension-flexion reversals with that produced during separated knee extension-flexion dyads. Because knee extension is preceded immediately by knee flexion during repeated reversals but not during separated dyads, this model seemed appropriate for our purpose. Given our findings with healthy subjects, I did not expect to find that reversal of antagonists affected knee extension torque production.

METHOD

My institution’s ethics committee approved the protocol for this investigation. A sequential medical-trials design was selected to compare between the knee extension torque produced during repeated knee extension-flexion reversals and the torque produced during separated knee extension-flexion dyads. I selected this design because it allows the confirmation of treatment effect with a minimum number of subjects.

Subjects who met the admission criteria for the study were admitted as they became available. The admission criteria required that subjects were affected by an intracranial lesion (cerebrovascular accident, tumor, or closed head injury), able to generate measurable static knee flexion torque in sitting, capable of completing knee extension through the full range against gravity, competent to follow instructions, and willing to grant informed consent. Two subjects had closed head injuries and six patients had cerebrovascular accidents (N = eight, four men and four women). Four were hemiparetic on the right and four were hemiparetic on the left. Subjects ranged in age from 21 to 79 years and were two months to two years postonset of the intracranial lesion.

Procedure

The knee extension torque generated during repeated knee extension-flexion reversals and separated extension-flexion dyads was measured on a Cybex® II isokinetic dynamometer.* Repeated knee extension-flexion reversals consisted of uninterrupted maximum voluntary knee extension-flexion reversals. These reversals, which were begun with the knee in full extension, represented the reversal of antagonist condition. Knee extension-flexion dyads consisted

* Cybex, Division of Lumex, Inc, 2100 Smithtown Ave, Ronkonkoma, NY 11779.
of a maximum voluntary knee extension followed immediately by a maximum voluntary knee flexion. After completing the knee flexion, a 15-second rest was taken before the pair or dyad was repeated. This exercise condition was selected because it did not involve a typical use of reversal of antagonists.

Patients were positioned on the Cybex testing chair with a trunk to thigh angle of about 95 degrees. I aligned the dynamometer input shaft with the knee and strapped the dynamometer lever arm just above the malleoli of the involved leg. Straps were used to stabilize each subject's involved thigh, pelvis, and trunk. I placed a wooden block behind the heel of the involved leg to prevent knee flexion beyond 90 degrees. The dynamometer chart recorder damping was set at two. The dynamometer speed was adjusted to 60/sec. This speed was selected because it is not normally associated with any knee-joint discomfort during exercise and because it allowed measurable torque production.

Before testing, each patient performed three warm-up contractions. Each patient performed eight repeated knee extension-flexion reversals and eight separated knee extension-flexion dyads. Contractions performed under the two conditions were separated by a three-minute rest. I randomly assigned the order in which patients performed under the two conditions.

In accordance with our usual clinical procedure, I took torque measurements from the four highest torque curves generated under each condition. The mean peak torques were calculated from these measurements and used to compare torque production during repeated extension-flexion reversals and separated knee extension-flexion dyads. If the mean knee extension torque during repeated knee extension-flexion reversals was 5% higher than the mean knee extension torque during separated knee extension-flexion dyads for a subject, then I judged knee extension-flexion reversals to be preferable for stimulating knee extension torque production in that subject and vice versa. The appropriate box of a sequential medical-trials grid for the .05 level of significance was checked, based on which treatment was found to be preferable for stimulating the greatest production of knee extension torque.

### RESULTS

Each of the eight subjects demonstrated higher mean peak knee extension-torque during repeated knee extension-flexion reversals than during separated knee extension-flexion dyads. The Table reports the mean, standard deviation, and range of knee extension torque under each condition. Using the sequential medical-trials design, knee extension torque was found to be greater during repeated knee extension-flexion reversals than during separated knee extension-flexion dyads ($p < .05$).

### DISCUSSION

The results suggest that for the type of patients tested and under the conditions of this investigation, repeated reversals result in the production of greater knee extension torque than do separated dyads. The findings, therefore, provide experimental evidence for the claim by Knott and Voss that reversal of antagonists is facilitatory. This evidence is more direct than that provided by previous studies, which could only be used legitimately to formulate a hypothesis.

Because each patient had greater torque production with repeated reversals than the torque production with separated dyads, only eight patients were required to establish the superiority of the repeated reversal treatment. This small sample, though legitimate, limits the conclusions that can be drawn from the sample. Clinicians are encouraged to test each patient to determine what treatment is best. By following this principle, I have continued to observe patients whose responses are different from those I reported in this study.

The findings of this study are somewhat different from those my associates and I obtained for healthy subjects. This difference may be a consequence of differences between the patients and healthy subjects. The patients in this study, like those evaluated by Watkins and associates, had weakness in their quadriceps femoris muscles and the healthy subjects did not. Furthermore, as I and Larkin noted, most of the patients in Watkins and associates' study were probably unable to generate dynamic knee flexion torque in excess of that resulting from the weight of their legs. Sahrman and Norton found the motor control of hemiparetic patients altered during reciprocal antagonistic contractions. Any of these factors may have influenced my results.

The experimental design my associates and I used in our previous study differed from the experimental design I used in this study. Using different experimental designs may have resulted in different findings. Patients had difficulty complying with the specific instructions my associates and I gave healthy subjects. Thus, the different experimental design was required for this study.

### Clinical Implications

Patients with intracranial lesions who perform repeated knee extension-flexion reversals at 60/sec will probably generate more knee extension torque if they do not pause between each dyad. Manually applied exercise in which antagonists contract sequentially might also be best performed without a pause between reversals. If time and equipment permit, each subject should be tested to determine what works best for him.

### CONCLUSION

Greater knee extension torque was produced at 60/sec by patients with intracranial lesions when they performed repeated reciprocal knee extension-flexion movements than when they performed knee extension-flexion dyads separated by 15 seconds. This finding seems to provide limited support for using the technique of reversal of antagonists.

### Acknowledgment

I gratefully acknowledge the assistance of Marian Geddie in the preparation of the manuscript.
REFERENCES

8. Armitage P: Sequential Medical Trials. Springfield, IL, Charles C Thomas, Publisher, 1960