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24. Holmes JR, Alderink GJ: Isokinetic strength characteristics of the quadriceps femoris and hamstring muscles in high school students. Phys Ther 64:914-918, 1984

APPENDIX
Method to Calculate Gravity Corrected Peak Torque
1. The lower limb is positioned exactly as for testing with all recorder and goniometer adjustments made as usual.
2. The speed is set at 30°/sec, the recorder to 30 ft-lb scale and 25 mm/sec chart speed.
3. The limb and input accessories are "weighed" by allowing the limb to fall passively from full knee extension (0°) through an arc of 90 degrees knee flexion.
4. Peak torque (GETθ)1 and the angle of peak torque (θ1) are measured from the resultant torque curve and position angle channel, respectively.
5. The gravity effect torque (GET) can be calculated now at any angle of knee flexion (θ2) using the formula adapted from Nelson and Duncan. The angle chosen (θ2) will be the angle at which peak torque occurs for the muscle being tested. Because peak torque occurs at different angles for the hamstring and quadriceps femoris muscles, a separate GET is calculated for each.
6. Each GETθ is added to the respective uncorrected quadriceps femoris muscle peak torque, and the GETθ is subtracted from its uncorrected hamstring muscle peak torque value to yield the gravity corrected hamstring and quadriceps femoris peak torque values.

Commentary
Fillyaw et al, in this article, and Nelson and Duncan in a recent article,1 should be commended for enlightening the clinician-researcher on this basic measurement error in isokinetic dynamometer testing in antigravity positions. In determining the strength of hamstring and quadriceps femoris muscle groups, the authors selected the most common isokinetic assessment area of the body.
Fillyaw et al have identified the effects of gravity in the recorded torque values at slow (60°/sec) and fast (240°/sec) velocities for the two muscle groups. This gravitational influence was termed gravity effect torque (GET), which was calculated by considering the combined weight of the dynamometer arm and the leg and foot.
The protocol Fillyaw et al used for determining the gravity correction factor was based on the method proposed by Nelson and Duncan.1 This procedure requires the subject to relax completely the knee extensor mechanism while the leg accelerates to a preset terminal velocity during a 90 degree range of motion. To ascertain complete relaxation of the extensor muscle group, I would recommend electromyograph monitoring, whenever possible, of the muscle group to ensure total relaxation. The clinically treated patient with a knee problem, for example, may have difficulty in willingly relaxing the muscles during this procedure. Thus, a number of trials may be necessary before a valid, reliable measure has been determined.
Fillyaw et al found a significant difference between peak torque values uncorrected and corrected for gravity at each velocity using the GET calculation. The quadriceps femoris muscle peak torque value increased, whereas the
hamstring muscle peak torque value decreased. I agree with the authors (based on my own research) that the GET influence will be greater as the limb velocity is increased.

Numerous studies have been reported in the literature in which hamstring and quadriceps femoris muscle peak torque scores have been determined at various preset velocities. In light of the present findings, those studies appear to have been developed on erroneous data. This fact, however, should encourage further research using the gravity correction factor to duplicate the earlier studies.

Frequently, during the evaluation of peak torque scores derived from knee isokinetic tests, a ratio of hamstring to quadriceps femoris muscle torque values is determined. Fillyaw et al determined this ratio and indicated a different finding in comparison with other earlier studies that had calculated the effect of gravity. In this study, the hamstring to quadriceps femoris muscle peak torque ratio decreased as limb velocity increased. The authors have provided ample explanations for the possible differences between the results of the various studies.

The earlier studies by Holmes and Alderink and Gilliam and others that did not use the gravity correction factor have cited this ratio as a key factor. Perhaps this concept of hamstring to quadriceps femoris muscle strength ratio has been overemphasized for actual value. This type of comparison between antagonistic muscle groups in other areas of the body is uncommon. One may question the merit in making this comparison. Numerous assumptions must be considered for this ratio analysis to be valuable. For example, the morphological composition within the muscle group and between the antagonistic muscle groups and the intersubject variability influence the ratio. Clinical judgments of the necessary muscle strength should be continued until more research evidence indicates that ratios are that important.

Although Fillyaw et al limited their analysis to calculating GET in relation to the peak torque value, this gravitational influence exists throughout the range of motion. Thus, any study in which the measurement of power has been calculated as the total area under the torque curve should consider the influence of gravity. Without this calculation included, the power value for antigravity movements and gravity-assisted movements will be underestimated and overestimated, respectively.

The results of Fillyaw et al may have been influenced by a systematic error, as acknowledged by the authors, resulting from the experimental design in which the testing sequence was the same for all subjects. A randomized block design would have been more appropriate.

My other concern involves the comparison of mean scores based on each subject’s five trials without reporting the reliability values. I would recommend an intraclass correlation technique for this type of study.

In summary, the authors have provided important information to everyone involved in isokinetic strength testing. Future studies involving gravity-assisted and antigravity movements, whether upper extremity, lower extremity, or trunk, must consider a gravity correction factor.

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Authors’ Response

We thank Merrifield for his thoughtful review of and lucid comments on our study. With respect to the procedure used to determine the torque resulting from the effect of gravity on the combined weight of the dynamometer arm and limb (GET), we agree with him that relaxation of the quadriceps femoris muscle is needed to ensure accurate measurement. This is important not only in the patient with a knee injury who, because of pain and apprehension may be unable to relax, but also in neurologically impaired patients. Recent reports on ambulatory patients with multiple sclerosis and hemiparesis have concluded that objective information about quadriceps femoris and hamstring muscle performance can be obtained in these patients with isokinetic testing. Investigators involved in isokinetic testing of neurological patients should be aware of the influence variable muscle tone may have on measuring GET and its subsequent effect on peak torque and ratio measures.

We also recognized the need to establish total relaxation to obtain a valid GET and plan to investigate the use of electromyographs and repeated trials as ways of ensuring a reliable determination of GET.

In suggesting that the hamstring to quadriceps femoris muscle strength ratio may be overemphasized, the commentator raises an interesting issue. Clearly, we cannot judge the utility of this ratio from our data, nor was this a purpose of our study. One wonders, however, if the ratio has value, beyond its present clinical use, as a measure of the relative strength of antagonists at a selected point in the range of knee motion. Here, presumably, the neuromotor and biomechanical factors are interact-