

# SPINAL REHABILITATION (Part 1)

## Measuring True Functional Ability In Clinical Practice

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Determining changes in functional ability (strength, range of motion and endurance) that are produced by various protocols during rehabilitation is the only objective mode available for evaluating the benefits of any treatment. We must know what has changed, the degree of change, and how the patient's functional ability at the conclusion of rehabilitation compares to normal with consideration of such factors as age, sex, size and previous exercise experience. In effect, we must be able to determine when the patient's function has returned to "normal."

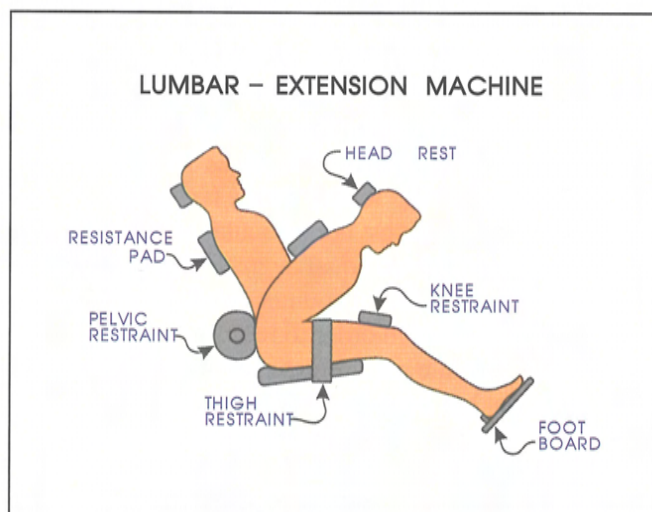
When dealing with an injured knee we usually have a normal leg for purposes of comparison, and when the functional ability of both legs is nearly identical we can be reasonably sure that rehabilitation has been successful; but when the lumbar spine or the cervical spine is involved in the injury, no such comparison is possible. Thus, with spinal injury, we must be able to recognize abnormal function, and this is now possible.

The first serious attempts to provide objective measurements of strength were made about twenty-five years ago, and millions of such tests have now been performed; but most of these tests were not objective and were not tests of true strength. Meaningful tests of strength have certain basic requirements that have usually been overlooked.

If strength is defined as the maximum level of torque that is produced by the force of muscular contraction, which is the only logical definition, then we must be clearly aware of several factors apart from the force of muscular contraction that also produce torque; factors that must either be removed or measured and factored into the test results in order to determine the true level of strength.

Another requirement for meaningful tests of strength is total isolation of the joint being tested; without such isolation it is impossible to determine the actual source of the torque that is measured. During

lower-back tests, if the pelvis is free to move, the measured torque will be a result of forces produced by muscles of the hips, the thighs and the lower back, and it is then impossible to determine just how much of the torque was actually produced by the muscles that extend the lumbar spine.



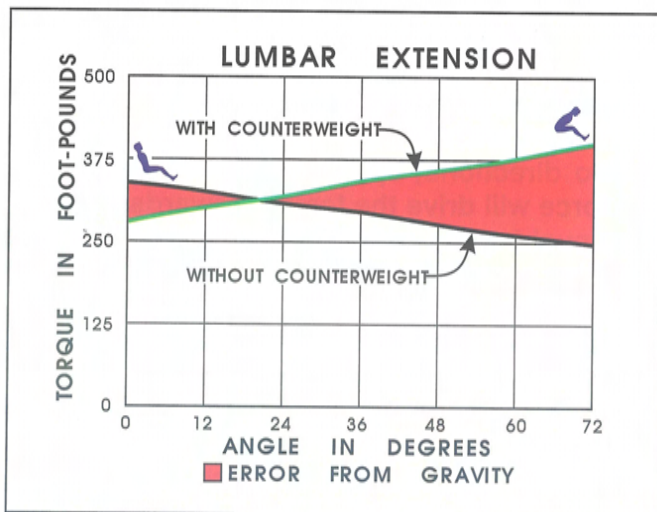
**FIGURE 1 - Pelvic Restraint - Total isolation of the lumbar spine requires anchoring the pelvis so that no pelvic movement is possible. Force imposed against the bottom of the feet is transmitted to the knee ends of the femurs by the lower legs, and will then produce resulting forces in two directions; approximately 70 percent of the force will drive the femurs towards the rear, thus pushing the pelvic/hip sockets to the rear; while an equal force will push the knee ends of the femurs upwards, which upwards movement is prevented by the knee pads; thus the wide belt above the upper thighs becomes a fulcrum which redirects the upwards force on the knees to a downwards force on the pelvic/hip sockets. The result being forces that push the pelvis towards the rear and downwards.**

While the functions of the hip and hamstring muscles, which work together to move the pelvis towards

extension of the back, are certainly important, it does not follow that weakness of these muscles is directly related to spinal pathology; the critical muscles in almost all cases of spinal pathology are the muscles that extend the lumbar spine, and the functional ability of these muscles can be determined only when they are tested in total isolation.

Providing the total isolation of the lumbar spine that is required for meaningful tests of spinal strength, range of motion and endurance required fourteen years of continuous research; successful isolation of the lumbar spine was provided only when the femurs were used for the purpose of anchoring the pelvis in such a manner that movement of the pelvis was impossible. But believing that the pelvis cannot move during testing procedures is not enough, we must know that the pelvis cannot move; and, eventually, this requirement was also provided.

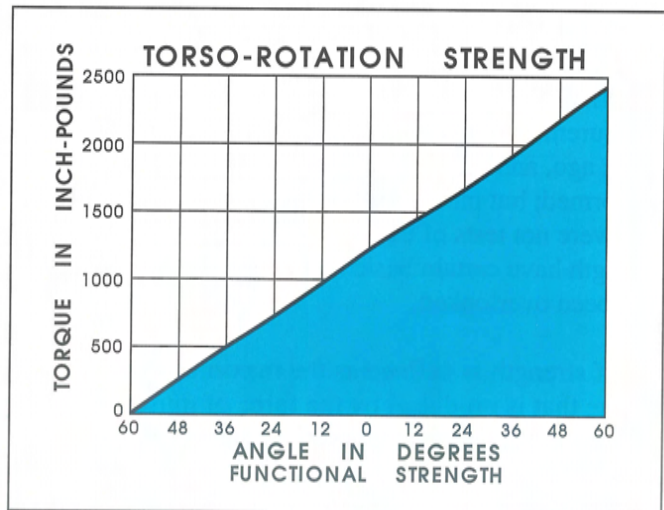
Having provided total isolation of the lumbar spine it then becomes necessary to deal with several other factors. Gravity acting upon the mass of the torso, head and arms will produce as much as 150 foot-pounds of nonmuscular torque with a large male subject in some positions; nonmuscular torque that will bias the test results to an equal degree. Meaningful test results thus require careful counterweighting of the subject's body-part mass in order to remove the effects of gravity. An absolute requirement for meaningful tests of strength that has been generally ignored; the result being that the measured level of maximum torque will be much too low in some positions and too high in other positions, will not provide a true test of strength.



**FIGURE 2 - Gravity** - This chart illustrates the effect of gravity on full-range strength tests of the totally isolated extensors of the lumbar spine.

The black curve shows the test results without compensation for the mass of the head, arms and torso; while the green curve shows the test results of the same subject with proper counterweighting. The differences in these two test results make the need for proper counterweighting obvious.

Your level of strength varies from one position to another throughout any full range of movement; variation in strength that results from changes in the leverage of the joint system as movement occurs, and from changes in the force of muscular contraction that occur during movement. So another requirement for meaningful tests of strength is the ability to determine the relative positions of the involved body parts; without which, apparent changes in strength may be indicated when no actual change in strength has occurred. An initial test result of 100 foot-pounds of torque, when compared to a later result of 200 foot-pounds of torque, would indicate a 100 percent increase in strength; but it is possible for a misleading test result to be produced if the two tests were not conducted in exactly the same positions; the second test might have been conducted in a position where the joint system provided much better leverage, or a position where the force of muscular contraction was greater, thus giving the impression that strength had increased when in fact no change in strength had actually occurred.



**FIGURE 3 - Position** - From the lowest to the highest level of measured torque through a full-range torso-rotation test this subject's strength varied in excess of 240,000 percent, an average change in strength of more than 2,000 percent per degree of movement. The need for accurate measurement of the relative positions of the involved body parts is thus obvious.

People have been trying to conduct measurements of the relative positions of the involved body parts during tests of strength for the last twenty years, but most of these attempts have been biased by unwanted movement of body parts; in tests of lumbar-extension any movement of the pelvis will be confused with movement of the lumbar spine.

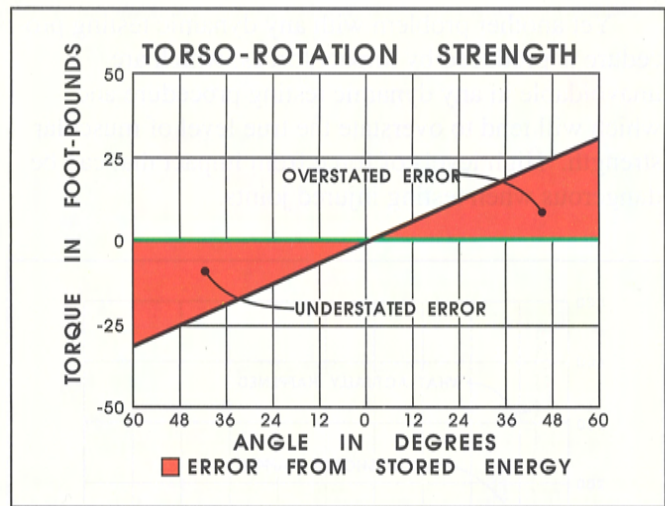
During a test of the strength of the muscles that rotate the torso in a longitudinal plane, if the pelvis is free to move it then becomes impossible to determine the true degree of spinal movement. The tested range of motion will be a meaningless measurement of rotation of the spine added to pelvic rotation; which will tell you nothing about spinal function.

So the pelvis must be prevented from moving in order to conduct meaningful tests of strength, or range of motion, in lumbar-extension tests or torso-rotation tests.

And the effect of gravity acting upon the mass of the involved body parts is not the only source of non-muscular torque that must be considered; torque produced by stored energy is another critical factor that is still being ignored during most testing procedures, and this will bias test results to such a degree that they are meaningless for any purpose if this factor is ignored.

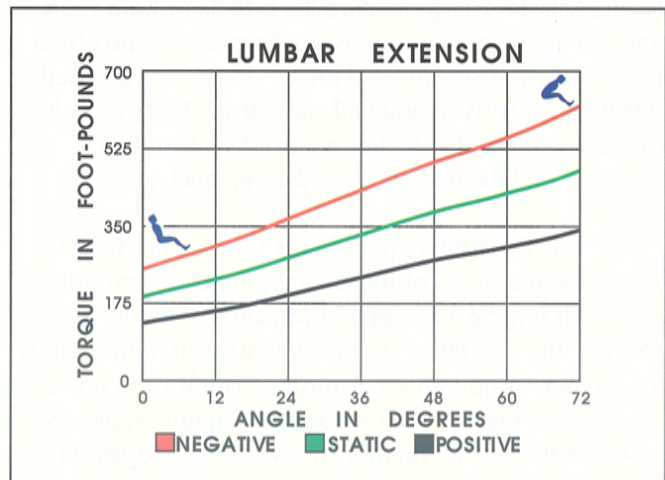
Movement in any direction away from a neutral, relaxed position results in compression of soft tissues on one side of a joint and stretching of soft tissues on the other side of the same joint, and such compression and stretching of soft tissues produces stored energy; which stored energy will produce very high levels of nonmuscular torque that will tend to move the involved body parts back towards the neutral position. Such nonmuscular torque from stored energy will overstate the true level of muscular strength in some positions while understating true strength in other positions. Regardless of the testing procedure used, nonmuscular torque from stored energy is unavoidable, cannot be removed; but it can be, and for meaningful tests of true strength must be, measured and factored into the test results.

Yet, in practice, this absolute requirement for meaningful tests of true strength is still being ignored in most testing procedures; the unavoidable result being that the tested levels of torque have no meaningful relationship with the true level of strength.



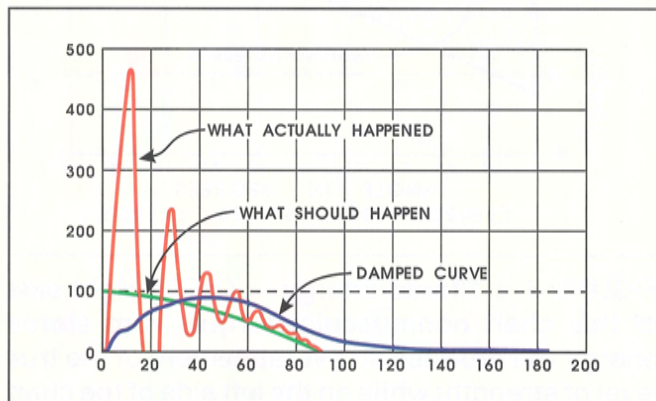
**FIGURE 4 - Stored Energy - On the right side of this chart nonmuscular torque from stored energy will produce an overstatement of the true level of strength; while on the left side of the chart torque from stored energy will produce an understatement of true strength.**

A third source of nonmuscular torque that is usually ignored is friction: during any test of dynamic strength the effects of friction are unavoidable, and the tested level of positive (concentric) strength will always be too low, having been reduced below the true level of strength by friction, while the tested level of negative (eccentric) strength will always be too high, having been increased above the true level of strength by friction. In either case, the test results are merely artifacts; do not indicate the true level of muscular strength.



**FIGURE 5 - Friction - Shown are three coexisting levels of fresh, full-range strength. Influenced by friction, positive strength is too low while negative strength is too high; only the test of static strength shows the true level of fresh strength.**

Yet another problem with any dynamic testing procedure is produced by impact forces; which are unavoidable in any dynamic testing procedure and which will tend to overstate the true level of muscular strength. High levels of force from impact that can be dangerous when testing injured joints.



**FIGURE 6 - Impact Forces - The green curve on this chart shows the test results that would have been produced if the testing machine being used actually measured torque, which it does not. The red curve shows what actually occurred during a supposed test of a known level of torque with a dynamic (isokinetic) testing machine. The blue curve shows the test results after they were distorted by an electronic "damping" device. Such tests cannot measure torque, instead record impact forces.**

But the solution to both of these problems, friction and impact forces, is simple; with the use of a static (isometric) testing procedure the effects of both friction and impact forces are removed. Friction has no effect upon static test results, and impact forces are avoided during a properly conducted static test. Tested levels of torque thus indicate the true level of muscular strength, and the testing procedure is much safer.

When all of the requirements for meaningful testing of the true level of muscular strength are provided, the result will be a test of Net Muscular Torque (NMT), the true level of muscular strength unbiased by any source of nonmuscular torque. But if even one of these critical factors is overlooked or ignored, the test results will have no relationship with the true level of muscular strength.

The research and development program that eventually produced testing equipment that was capable of meaningful measurements of true strength and true ranges of motion has been continuously ongoing for more than twenty years and required a total investment

now exceeding \$83,000,000.00; during the last ten years this research has been conducted in direct cooperation with the School of Medicine of the University of Florida, Gainesville, and for the last two years in cooperation with the Department of Orthopaedics and Rehabilitation at the School of Medicine of the University of California, San Diego.

During the last seven years a team of researchers headed by Michael L. Pollock, PhD, at the School of Medicine in Gainesville, conducted a total of forty-four research programs utilizing this equipment; research involving thousands of subjects, tens of thousands of testing procedures, and hundreds of thousands of exercise sessions.

At the moment, January 1993, 700 patients with chronic spinal pathology are being evaluated and rehabilitated with this equipment every week in San Diego by a team directed by Vert Mooney, M.D.; with outstanding results with more than eighty percent of such chronic patients.

Additional research with thousands of chronic spinal patients has been conducted in several other locations in this country, in Japan and in Europe; with outstanding results in all cases.

And hundreds of thousands of patients with chronic spinal pathology are now being rehabilitated in several hundred clinical facilities in this country, in Canada, in Japan, in Australia, in Korea and in several countries in Europe.

If you are involved in functional testing or rehabilitation you can obtain a free copy of a forthcoming book, "The Lumbar Spine, the Cervical Spine and the Knee," by writing on your professional stationary. This book covers everything that is currently known on the subjects of functional testing and rehabilitation; all of which information is clearly spelled out and illustrated with color photographs of both testing procedures and test results.

Requests for the free book should be addressed to: MedX Corporation, 1401 NE 77th Street, Ocala, Florida 34479.

Copies of research studies performed in Gainesville can be obtained by writing to: Dr. Michael L. Pollock, Department of Medicine, University of Florida, Box J-277, JHMHC, Gainesville, Florida 32610.