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The following pages contain an advance look at four chapters from an important new book, ***The Lumbar, The Neck and The Knee***

Lumbar Function

Lumbar function is not what it appears to be. Not what it is generally believed to be. Hundreds of books and thousands of articles have been published on the subject of lumbar function; yet many of the generally accepted opinions are wrong, and some are dangerously wrong.

In some respects, lumbar function is quite simple . . . but in other ways it is very complex. The primary purpose of the lumbar is to move the torso in relation to the pelvis; but for all practical purposes, such movement is limited to extension . . . the normal lumbar spine cannot rotate and cannot flex, cannot move forward beyond a straight alignment of the vertebra.

The shape and interlocking relationship of the spinal facets prevent longitudinal rotation from the sacrum through T11. The lowest seven vertebra and the sacrum are locked together by the facets in such a manner that rotation is nearly impossible without damage to the bones.

Published reports of vertebral rotation in the lumbar are usually wrong; probably resulting from a failure to notice that the pelvis was moving during the attempts to measure lumbar spinal rotation. Perhaps resulting from conducting such tests with cadavers, where lumbar rotation can be forced if the applied forces are high enough. But with a living subject, very little in the way of lumbar rotation can be produced without damage to the spine.

The muscles, ligaments and facets of the lumbar are designed for four interrelated purposes . . . one, to move the lumbar vertebra in the direction of extension . . two, to prevent lumbar rotation . . . three, to prevent lumbar flexion . . . four, to limit lateral bending.

Meaningful measurements of lumbar function can be produced in only one way . . . by isolating and anchoring the pelvis; if the pelvis is free to move, then any attempt to measure lumbar function is doomed to failure. Instead of testing lumbar function you will unavoidably be measuring some unknown combination of hip function and lumbar function. Confusing the strength of the hip and thigh muscles with the strength of the lumbar muscles. And confusing hip movement with lumbar movement.

The muscles of the buttocks and thighs can move the pelvis with enormous levels of force, rotating the pelvis around the heads of the femurs . . . and any such movement of the pelvis will produce an equal degree of movement of the lumbar, since L5 is connected to the sacrum. Thus lumbar movement can and does occur even when the lumbar muscles are totally relaxed.

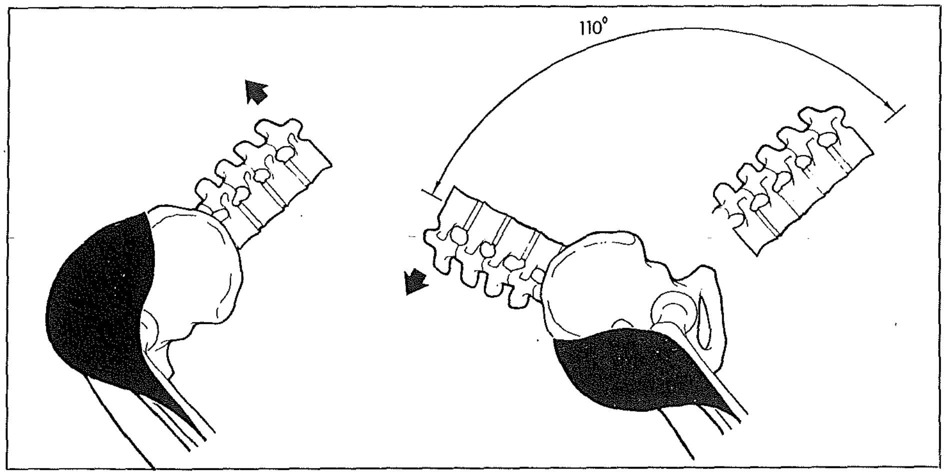


FIGURE 1: **A comparison of these two figures gives a clear illustration of back extension that does not involve lumbar function. Lumbar movement, but not lumbar function . . . the lumbar vertebra maintained the same relative positions to one another and to the sacrum throughout the movement, and the muscles of the lumbar maintained the same length throughout the movement.**

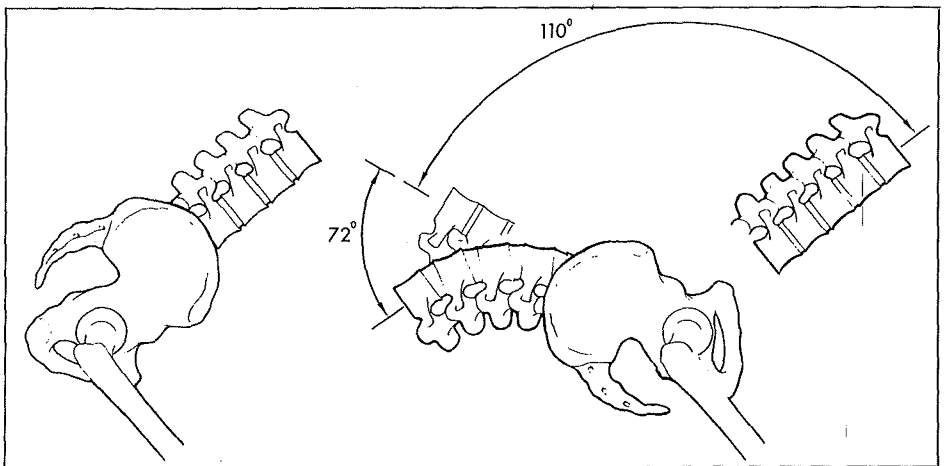


FIGURE 2: **These figures show the type of compound movement that is usually involved in trunk extension; movement of the pelvis produced by the muscles of the hips and thighs . . . with simultaneous movement of the lumbar vertebra in relation to the pelvis produced by the lumbar-extension muscles.**

Meaningful measurements of lumbar function cannot be produced during either of the two distinct types of movement illustrated in the above examples. The first example does not involve lumbar function . . . and the second example involves compound rotation and compound muscular contractions that confuse hip function with lumbar function. In either case, even if the test results are accurate, they tell you nothing about lumbar strength or lumbar range of movement.

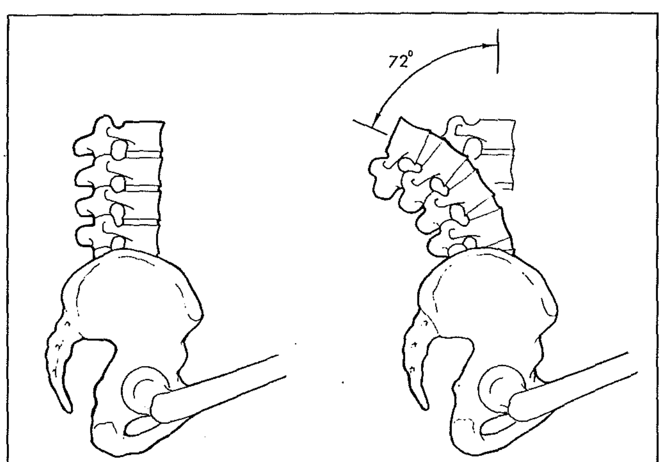


FIGURE 3: **The figures to the left illustrate lumbar function in total isolation; the lumbar vertebra rotate to the rear in relation to the sacrum, but the pelvis does not move . . . must not move if you are attempting to measure either the range of movement or strength of the lumbar.**

Anchoring the pelvis in order to isolate the lumbar is only the first of more than a dozen absolute requirements for meaningful measurements of lumbar function . . . but many of the additional requirements will be covered in a following chapter, so I will limit my remarks in this chapter to points that must be mentioned for a clear understanding of lumbar function.

Meaningful lumbar function is limited to extension . . . rotation towards the rear; rotation occurring simultaneously around five distinct points . . . between L5 and the sacrum, and below each of the other four lumbar vertebra. A normal range of movement will usually be between about 60 degrees of rotation and 75 degrees of rotation. Much less than 60 degrees is indicative of pathology . . . and anything in excess of 75 degrees is abnormal.

If all of the five joints are free to move in an unrestricted manner, then the average movement will range from a low of about 12 degrees per joint to a high of about 15 degrees per joint.

It is generally believed that an extreme degree of extension, so-called hyper-extension, produces compression forces on the lumbar discs by reducing the vertical distance between the vertebra along the rear faces of the vertebra . . . thus compressing the discs. Quite the opposite is true.

Rather than compressing the discs in the rear, hyper-extension actually increases the disc space along the rear face of the lumbar vertebra . . . instead of increasing the forces on the discs, hyper-extension reduces the force on the discs. But it is dangerous . . . not dangerous to the discs but to the facets.

Because . . . the axis points of rotation of the lumbar vertebra change as extension occurs. Extension much past lordosis moves the axis far to the rear, into the facets.

During movement in the direction of extension . . . starting from the flexed position, and ending in the position of normal lordosis . . . the axis of rotation of each of the involved joints is located to the rear of the front face of the vertebra, and to the front of the rear face of the vertebra. But the exact axis is difficult to locate.

During that part of the movement, the axis points are between the vertebra . . . so any movement in the direction of extension will increase the disc space in the front while reducing the disc space in the rear.

The disc spaces, front and rear, are approximately equal only when the lumbar spine is in the flexed position (straight).

In the normal position of lumbar lordosis, the disc space is increased in the front and reduced in the rear.

If the axis points of rotation remained in their original positions, then continued movement to the rear from a lordotic position would increase the disc space in the front while reducing it in the rear . . . but this does not occur.

Instead . . . extension much beyond a point of normal lordotic curve increases the disc space both front and rear. Because the axis points of rotation move to the rear . . . move a long way to the rear. Extension much beyond a normal lordotic curve involves rotation around axis points that are well behind the rear face of the lumbar vertebra.

Hyper-extension has been a buzz word in the field of medicine for at least fifty years that I am aware of . . . it having been generally assumed that hyper-extension was dangerous because it squeezed the discs between the rear edges of the vertebra.

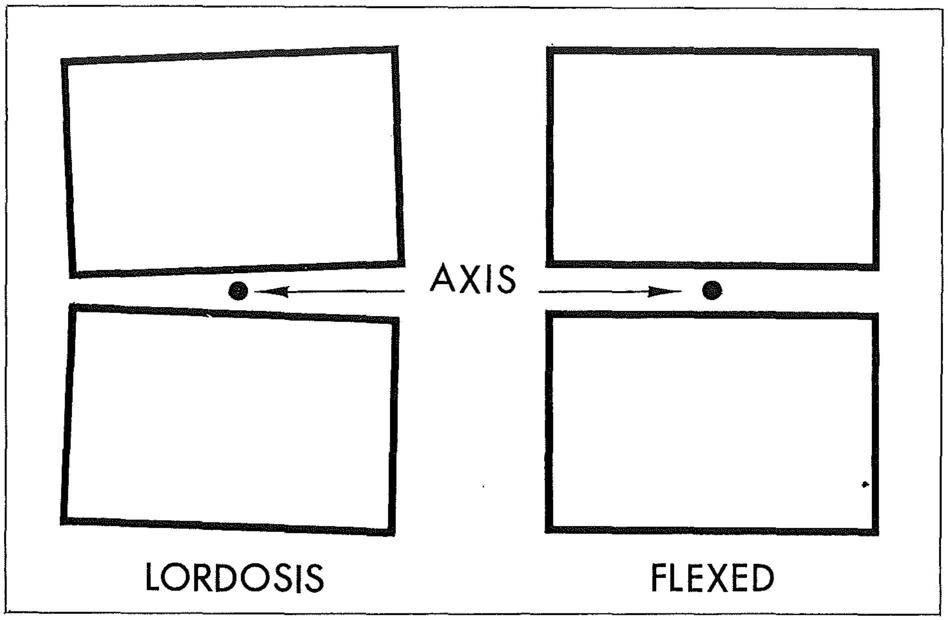


FIGURE 4: **A comparison of these two figures demonstrates what occurs in the disc space as you move from a flexed position towards a lordotic curve. The disc space increases in front while decreasing in the rear. Which relative changes in disc space mean that the axis of rotation is somewhere between the front and rear surfaces of the vertebra . . . to the rear of the front surface, to the front of the rear surface.**

If the profile view of a vertebra was a perfect rectangle with square edges, then it would be possible to determine the exact axis of rotation . . . but the irregular shape of the vertebra makes this very difficult.

X-rays, CAT-scans and magnetic resonance illustrations all suffer from a common problem . . . it is impossible to determine the precise surface of either the top or the bottom of a vertebra. Thus it is impossible to accurately measure the range of rotational movement by comparing the top of a vertebra in one position to the top of the same vertebra in another position.

And very difficult to measure the changes that occur in the disc space as a result of movement.

But even without the ability to measure these changes in disc space with great accuracy, a comparison of any two of the lumbar vertebra in a flexed position to the same two vertebra in a position of lordosis will make it obvious that the front disc space has opened while the rear disc space has closed.

It has generally been assumed that continued extension beyond a position of normal lordosis would open the front space even wider, which in fact is what happens . . . but it has also been assumed that such continued extension would reduce the rear disc space even more, and this does not happen. Instead, extension much past lordosis opens the disc space both in the front and in the rear.

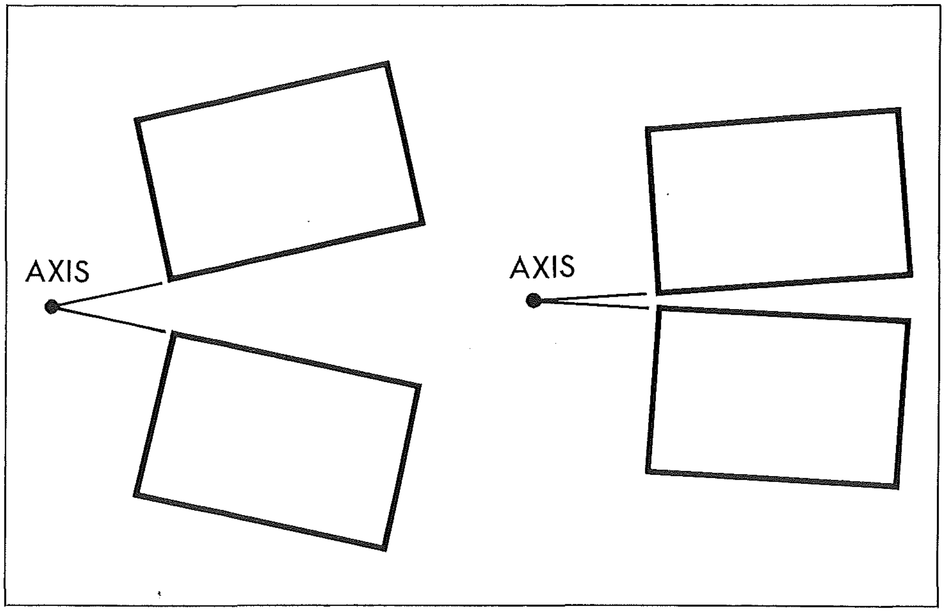


FIGURE 5: **Extension much beyond a position of normal lordosis opens the disc space both in the front and in the rear . . . because the axis of rotation has moved, is no longer between the vertebra, is relocated to a position behind the rear face of the vertebra.**

Thus the initial movement, from a straight spine to a lordotic curve, involves rotation around an axis located between the vertebra . . . while continued movement much to the rear of a lordotic curve involves rotation around an axis located behind the vertebra, an axis located in the facets.

In fact, hyper-extension reduces the force on the rear face of the discs . . . but it is dangerous.

Dangerous for another reason . . . dangerous because it imposes enormous levels of force on the facets.

Since it is impossible to establish the exact positions of either the top or the bottom of a particular vertebra . . . and since the front face of a vertebra is not a straight line, is generally concave in the center, it is also very difficult to measure range of movement by attempting to compare the front face of a vertebra in one position to the same front face in another position . . . difficult, at least, until the problem is approached in the following manner.

Many books and articles have suggested a wide variety of methods for accurately measuring the relative movements of the lumbar vertebra . . . none of which methods are very accurate . . . some of which are meaningless.

But it can be done with great accuracy . . . if the following procedure is understood and applied.

The primary problem with attempts to measure vertebral movement results from the lack of a fixed reference point . . . we can never be sure of the exact position of either the top or the bottom of a vertebra, the corners of the vertebra are too irregular in shape for accurate comparison, and the front surface (the face) of a vertebra is seldom a straight line. Additionally, the perspective changes as a vertebra moves from one position to another. Thus we have no fixed reference point on or in the vertebra that maintains its position without a change in perspective as movement occurs.

If we had a straight line scribed onto the side of the vertebra, a line that would show up on an x-ray, then the required reference point would be provided. But since this is not the case, we must establish an equally reliable reference point in another manner, in a practical manner . . . and we can.

In an x-ray, the only part of a vertebra that maintains the same perspective in all positions is the front face . . . coincidentally, but fortunately for our purposes, the front face of the vertebra is also the clearest and sharpest part of the vertebral picture; this being true for two reasons . . . because the rear face of the vertebra is confused with the facets, and because both the top and bottom of the vertebra are confused because an x-ray provides a picture of both the near side and the far side of the vertebra.

Thus the front face provides the clearest picture; the problem being that the face is not a straight line.

But such a line can be established; by scribing a perfectly straight and very narrow line on the x-ray picture, a line that barely touches both of the two most forward bumps on the front face of the vertebra. Such a line may not be parallel with the midline of the vertebra, probably will not be; but this matters not at all . . . because the relationship of such a line to the rest of the vertebra will be a constant in any position. Thus we know that any change in the position of this line is indicative of an equal change in the vertebra.

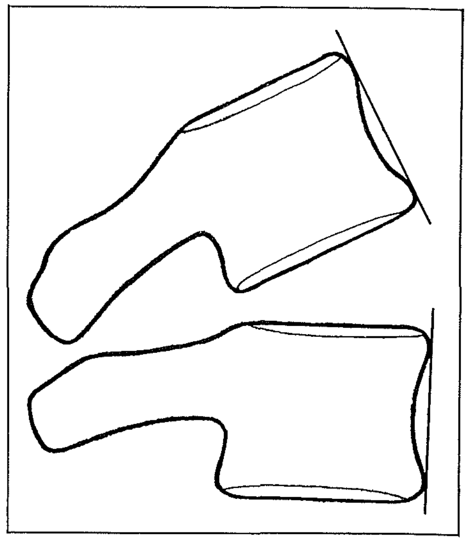


FIGURE 6: **Scribing a thin, straight line on the x-ray picture in the manner illustrated here . . . a different line on the front of each vertebra . . . will provide an almost perfect source of reference points for establishing the angular relationships of the five lumbar vertebra in any position from a straight spine to a fully extended spine.**

These lines will tell you nothing about changes in disc space that occur as a result of rotational movement . . . but they will provide an almost perfect method for measuring the movement of each of the five lumbar vertebra.

Which leads to the next problem . . . attempting to establish the relative positions of L5 and the sacrum, and the changes that occur as movement occurs.

X-ray pictures of the sacrum, in a lateral view, are never as clear as the front faces of the vertebra . . . because the sacrum is confused and blurred by the near side of the pelvis. But again fortunately for our purposes, the front face of the sacrum has rather distinct bumps that show up as points in a lateral x-ray picture. Select any two of these bumps that are shown on all of your x-ray pictures and scribe a line that barely touches the most forward points on these bumps.

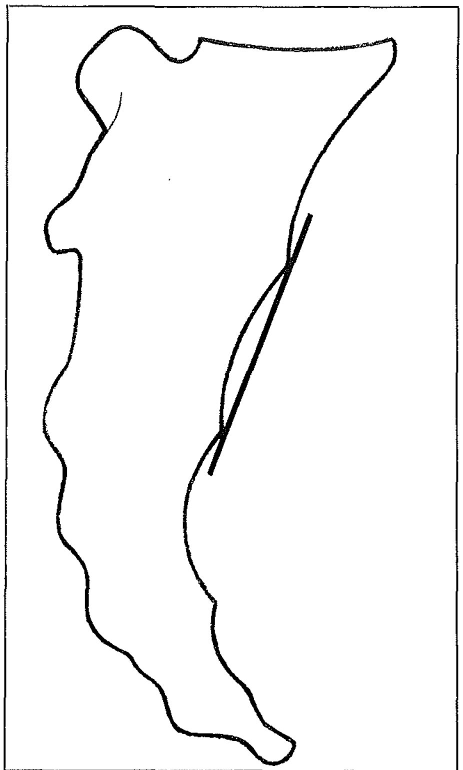


FIGURE 7: **Having established this scribed line on the front face of the sacrum, you now have a means of measuring angular changes between L5 and the sacrum. By comparing changes between the six lines in several positions it then becomes possible to determine the exact angular movement of the lumbar vertebra in relation to each other and in relation to the sacrum. Total range of movement can then be determined with a very high degree of accuracy . . . and of even greater importance, it is then possible to determine exactly how much movement occurs between adjacent vertebra. Even when the total range of lumbar movement appears to be normal, it does not follow that all five vertebra are rotating in proper proportion . . . or even that any movement is occurring between some of the adjacent vertebra.**

Having established those six lines, you can then measure angular changes in vertebral position . . . but you still have no means for measuring changes in disc space . . . nor do you have a means for locating the axis points of rotation.

But this can also be done . . . and again with a very high degree of accuracy.

Pick a point along the line on the front face of each of the five vertebra and on the sacrum . . . an arbitrary point, but a point that is below the top of the vertebra and above the bottom of the vertebra . . . then scribe a second thin line on the x-ray picture; a line that is perpendicular to the first line (90 degrees out of phase, a perfect right angle in relation to the first line) . . . and a line that is exactly one inch long, or exactly 25 millimeters long, or any other exact length so long as this line does not extend as far as the rear face of the vertebra.

The length of this second line is unimportant, provided it is not too long, and is always the same length in all cases.

Nor is the vertical positioning of this line important . . . so long as it is not above the top of the vertebra or below the bottom of the vertebra.

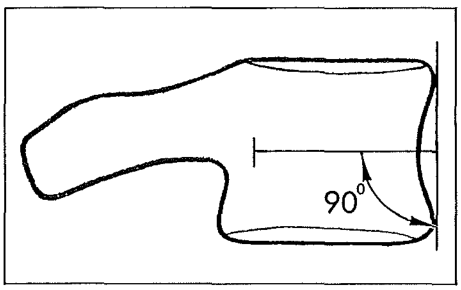


FIGURE 8: **Our second scribed line, perpendicular to the first line, indicates changes in disc space that result from movement. Tells us whether the spaces are increasing or decreasing . . . and tells us the location of these changes in any given position.**

It does not provide a measurement of disc space . . . but it does clearly indicate either an increase or a decrease in disc space.

Which, for our purposes, is all that we require. An accurate measurement of disc space would be convenient, but is not required.

It would be convenient for our purposes if this second line could be positioned at the precise midpoint of the vertebra, exactly midway between the top and the bottom of the vertebra . . . would be convenient, but is not possible, is not possible because we cannot determine the midline of the vertebra . . . would be convenient, but is not necessary for our purposes. All that is required is that this second line is perpendicular to the first line and that it has an exact length . . .

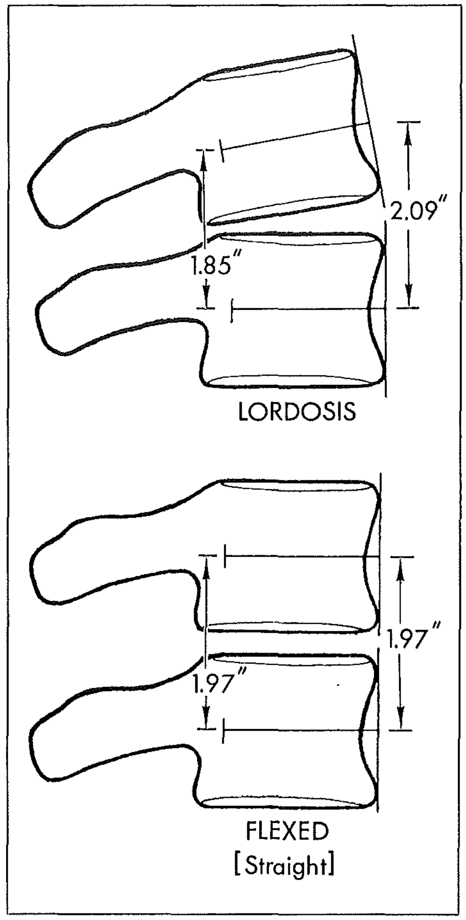


FIGURE 9: **A comparison of these two drawings should make the previous points very clear. In this illustration the front distance increased while the rear distance decreased . . . making it obvious that the disc space was opening in front while closing in the rear.**

almost any length, but always the same length.

It is also helpful if a short line is added at the far end of this second line . . . a short line perpendicular to this second line; which serves as a clear mark indicating the end of this line.

In order to measure disc space, it would be necessary to establish the exact top of one vertebra and the exact bottom of the adjacent vertebra, and this is not possible because of the problems inherent in x-ray pictures.

But it is possible to establish that changes in disc space are occurring with movement, and where such changes are occurring, and whether the changes produce an increase or a decrease in disc space.

But this will not always happen . . . sometimes the vertical distance between the two lines will increase

The greatest lumbar spine length occurs in maximum extension

both in the front and in the rear. When this occurs, then it is obvious that we have an entirely different situation . . . but the solution in such cases is not so obvious; now we must deal with geometrical relationships and mathematical calculations that are required for the purposes of determining the location of the axis of rotation and the relationship between the disc spaces on the front and rear faces of the vertebra. Which is possible but seldom necessary.

Such relocation of the axis points of rotation produces other results as well . . . results that have nothing to do with the length of the lumbar, but have a great deal to do with the strength of the lumbar.

In the flexed position, when the spine is straight, the axis points of rotation are located somewhere

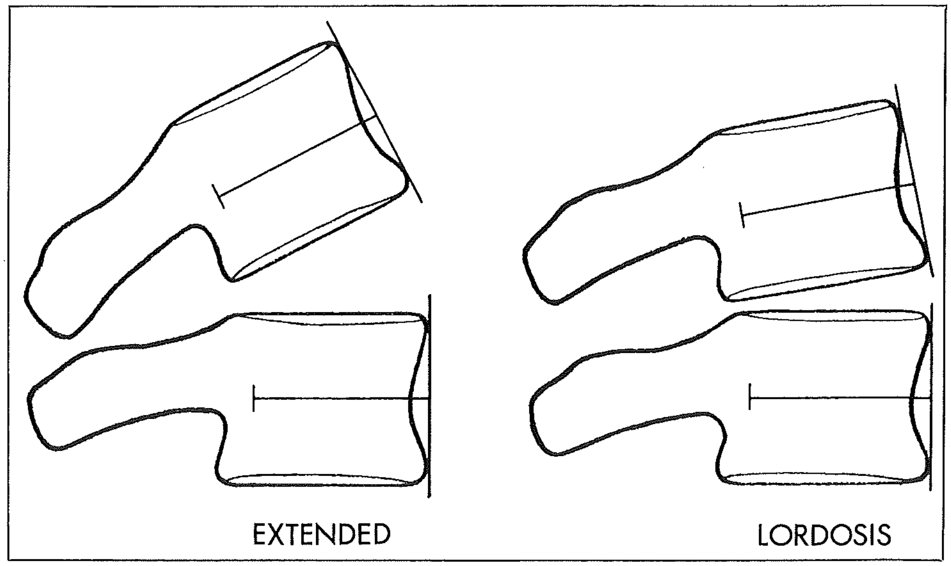


FIGURE 10: **Continued movement past a lordotic position, in the direction of extension, will eventually produce an increase in disc space both in the front and in the rear . . . and it also produces another result, a rather surprising result; the overall length of the spine changes during extension, changes in both directions . . . first becomes shorter than the length in the straight starting position, then becomes longer. The greatest overall length of the lumbar spine occurs in a position of maximum extension.**

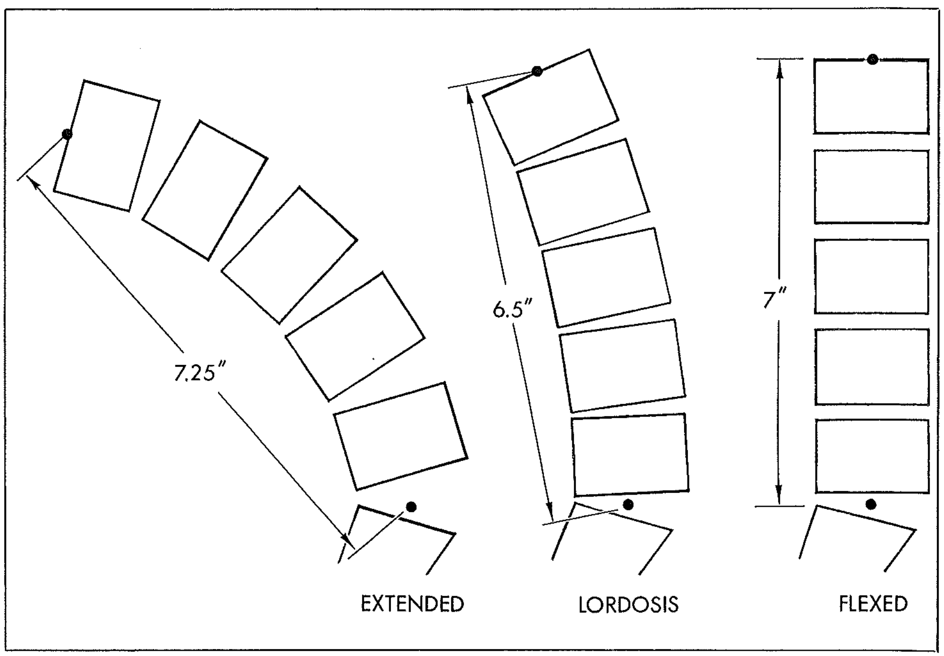


FIGURE 11: **If a point is marked between the bottom of L5 and the sacrum, and another point on the top of L1 . . . and if the straight-line distance is measured between these points . . . then it will be shown that the longest distance occurs when the spine is extended, the shortest distance in a position of lordosis, with an intermediate distance when the spine is flexed.**

The extended spine is not a great deal longer than the straight spine, but is a lot longer than the spine with a lordotic curve. This surprising increase in spine length between the lordotic position and the extended position occurs because the axis points of rotation are relocated to the rear; rotation occurs around points well behind the vertebra, axis points located in the facets. The result being that the vertebra are pulled apart to such an extent that the overall, straight-line length of the lumbar spine is increased to a marked degree.

The lumbar section of the spine contains some of the most efficient major joints

between the vertebra . . . but the input of muscular force is pulling at a point that is far to the rear of the axis . . . and the input of force is parallel to the possible direction of movement. The muscles are wasting none of their force by pulling in the wrong direction . . . and, secondly, the muscles are provided with an enormous mechanical advantage.

In that position, the muscles are provided with at least a two-to-one mechanical advantage . . . in some cases perhaps as much as a four-to-one advantage. Meaning that the extension muscles of the lumbar, in that position, may produce a pulling force of only 100 pounds while producing an output of functional force of at least 200 pounds, and perhaps as much as 400 pounds.

The extremely complicated interrelationship of the lumbar facets and the lumbar extension muscles is such that it is simply impossible to measure this mechanical advantage with anything even approaching a high level of accuracy . . . but it is obvious that such a mechanical advantage exists.

Which is fortunate indeed, literally essential for lumbar function; because the lumbar muscles themselves are rather small, and relatively weak. Without this enormous mechanical advantage, the lumbar muscles would have to be many times as large as they actually are . . . in which case the size of the required muscles would be so great that they would limit the range of possible lumbar movement.

A similar situation exists in the neck muscles of a rhino, but without the mechanical advantage found in the human lumbar; the result being the huge lump of muscle located above the shoulders of a rhino, an enormous mass of muscle that is required because the necessary degree of mechanical advantage is not provided in their cervical vertebra.

An extreme example of a mechanical disadvantage is found in the human knee; where more than 90 percent of the muscular force is wasted . . . the result being that only about eight percent, or less, of the force produced by the quadriceps muscle is actually usable for the purpose of extending the lower leg around the axis of the knee.

Additionally, because of the relative angles of pull in some positions, the compression forces on the knee during leg extension are far higher than the level of force being produced by the quadriceps.

In one instance that I will cover in more detail in a later chapter, one of our research subjects was capable of producing an accurately tested output of 654 foot-pounds of torque in the leg-extension movement . . . and in order to produce such an output of force his quadriceps muscles were required to produce at least 7,350 pounds of pulling force. Which also means that the compression force imposed upon his knees was something in excess of 10,000 pounds in some positions.

Which is why your femurs are so strongly constructed . . . they must be strong in order to withstand the forces produced by the quadriceps and magnified by the angle of pull in some positions.

Which is also why knee problems are so common.

The knee is probably the least efficient major joint in the body . . . and the lumbar section of the spine contains some of the most efficient major joints in the body. If the situation were reversed then you would be built like the Hunchback of Notre Dame but with the thighs of a flamingo.

In a position of lumbar flexion, the muscles of the lumbar are at least twenty-five times as efficient as the quadriceps of the thighs . . . perhaps as much as fifty times as efficient.

But that advantage of leverage exists only when the spine is straight . . . then, as the vertebra move to the rear during lumbar extension, things change. Two changes occur simultaneously; both of which changes produce losses in functional strength.

One . . . the axis of rotation moves towards the rear, thereby reducing the previously-existing advantage in leverage. Two . . . the angle of pull of the muscles is changed as the facets rotate downwards, thereby reducing the effective strength of the muscles.

A large part of the mechanical advantage is lost, even reversed, and the muscles are no longer pulling in exactly the proper direction; the net result being a great loss in functional strength.

But even in their worst position, having lost the mechanical advantage and with the muscles no longer pulling in the proper direction, the muscles involved in lumbar extension are still far more efficient than the quadriceps muscles.

An efficiency provided by the bony structure of the lumbar, not by the strength of the lumbar muscles. The vertebra and their related facets are simply a masterpiece of structural engineering; in comparison, the knee is an outrage.

The more I study the lumbar, the more impressed I become by its design.

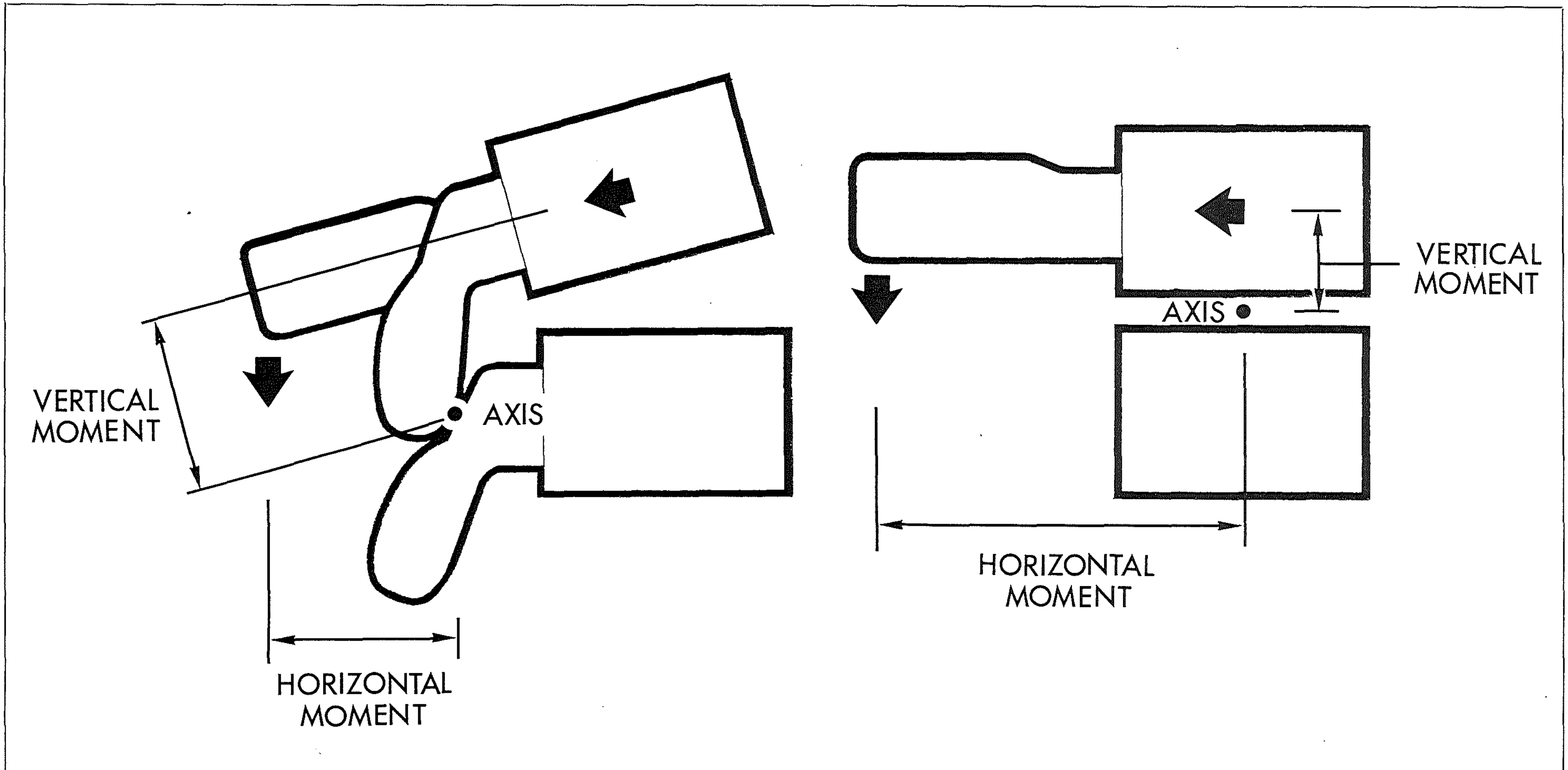


FIGURE 12: **A comaprison of these two drawings will clearly demonstrate the changes in both leverage and muscular efficiency that result from movement in the direction of extension of the lumbar vertebra.**

When the lumbar spine is straight, in the flexed position, the muscles are provided with an advantage of leverage; the input of force by some of the muscles is provided at a point far to the rear of the axis of rotation . . . while the output of force is produced at a point much closer to the axis. Meaning that the output of force will be at least twice as great as the actual input of muscular force. The measurable output of functional strength is thus twice as high as the actual level of muscular strength. But only in that position; then, as movement occurs towards extension, things change.

When the lumbar spine is extended to its limit of travel toward the rear, the axis of rotation has moved . . . has moved a relatively great distance, and has moved in two directions. Has moved back and down; is now located far to the rear of the vertebra, in the facets . . . to the rear of its initial location and below its initial position.

Moving the axis to the rear and downwards reduced the horizontal moment-arm (horizontal in a standing subject) while increasing the vertical moment-arm . . . the result being that the initial advantage in leverage is reversed; the muscles are then provided with a disadvantage of leverage. In that position, the measurable output of functional strength will be less than the actual strength of the muscles.

Secondly. . . when the spine is straight, the muscles are pulling in exactly the proper direction, so none of the muscular force is wasted by pulling in the wrong direction. But in the extended position of the spine, the muscles are no longer pulling in exactly the right direction . . . a meaningful percentage of the force produced by the muscles is wasted because it is being exerted in a less advantageous direction.

Both of these factors, changes in the axis of rotation and changes in the direction of pull of the muscles, combine their effects to produce a gross reduction in your functional strength as you extend your lumbar spine.

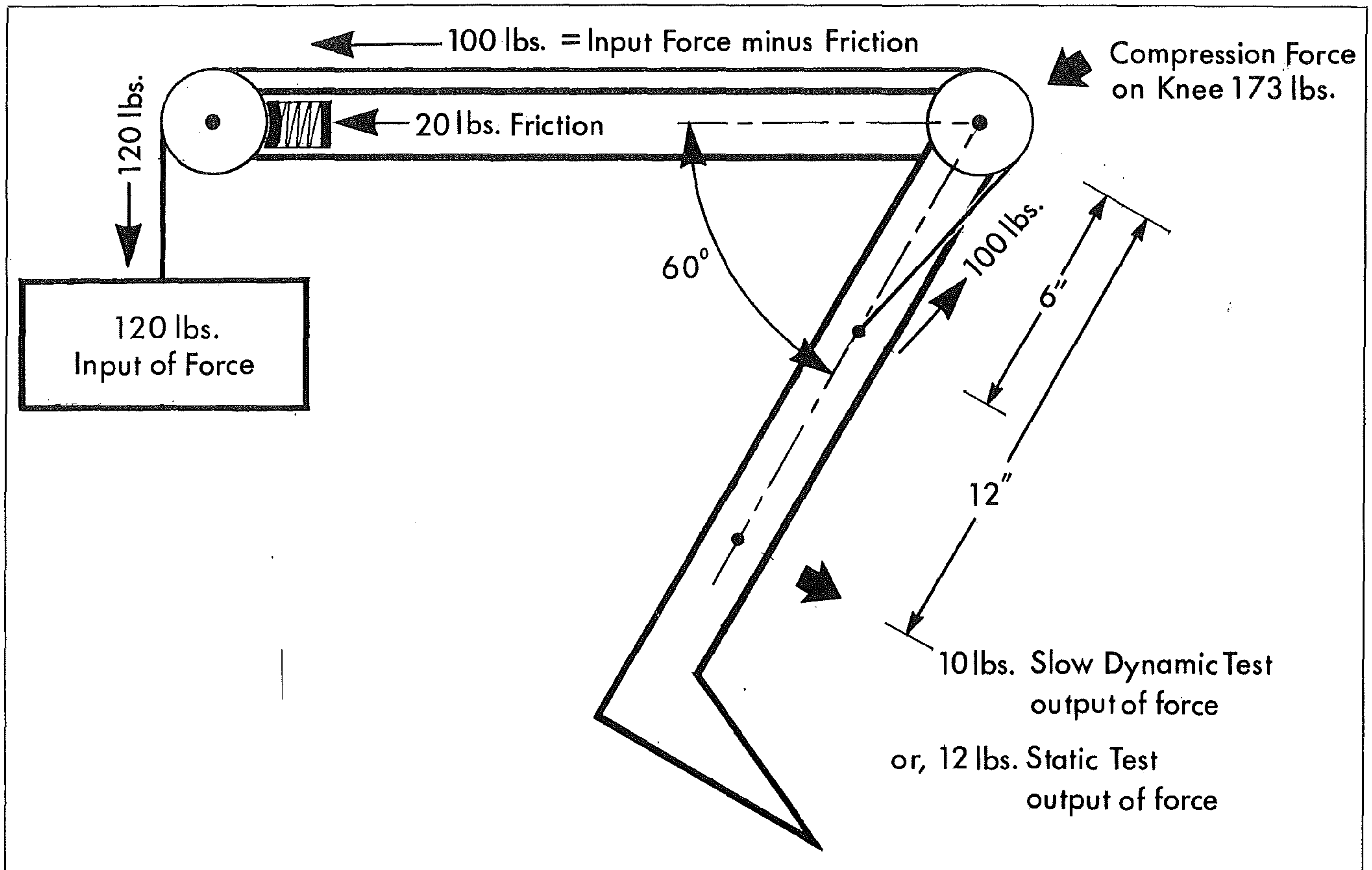


FIGURE 13: This drawing provides a simple example of the factors involved in the mechanical disadvantage existing in the knee joint. The knee probably being the least efficient major joint in the body.

If a force of 120 pounds is produced by the quadriceps muscles, illustrated by the hanging weight in this drawing . . . then only 100 pounds of that force will be exerted on the top of the patella, because 20 pounds of that force will be wasted by the internal muscular friction within the muscle.

The remaining 100 pounds of force will then be redirected around the axis of the knee by the patella . . . and then transmitted by the patellar ligament to the lower leg.

Will be pulling on the bone of the lower leg at a point that is only a short distance below the axis of rotation of the knee . . . but the point of attachment to the lower-leg bone is not the effective point of attachment; the effective point of attachment is actually located a relatively much greater distance below the axis of the knee.

Effectively, the point of attachment is located where the extended line of pull of the patellar ligament intersects the midline of the bone; which serves to improve the situation considerably . . . a situation that badly needs improvement, a situation that is still very poor even with this help.

At that effective point of attachment, the force pulling on the bone of the lower leg is still 100 pounds . . . but it is pulling in the wrong direction; is pulling at an angle that is less than 12 degrees away from the midline of the lower-leg bone . . . which means that at least eighty percent of the force is being wasted, does not serve to move the lower leg, tries to reciprocate the lower leg rather than rotate the lower leg.

The lower leg cannot reciprocate, can only rotate in one direction . . . so the usable force in that position is less than twenty percent of the force being exerted.

Which is bad enough . . . but it gets worse, for two reasons. The output of force is measured farther down the lower leg, at a distance that is approximately twice as far below the axis of the knee as the effective point of attachment of the patellar ligament . . . which serves to cut the output of functional strength in half. Reducing the output of measurable force to only 10 pounds.

Which means that the input of force by the muscle of 120 pounds has been reduced to an output of only 10 pounds by the time it reaches a point a foot below the axis of the knee . . . the point at which strength is measured, in foot-pounds of torque.

Since the foot is located even farther below the knee, this means that the functional strength has been reduced even more at that point . . . if the foot is 18 inches below the axis of the knee, then the output of force at the foot would be only six and two-thirds pounds.

Would be if that was the only factor, which it is not; additionally, we have another problem above the patella, a problem I have not mentioned yet, a situation not illustrated in the above drawing.

All of the above assumes that the output of force from the quadriceps muscle is pulling against the top of the patella in exactly the right direction . . . which it is not; instead, a meaningful percentage of the force produced by the muscle is pulling in the wrong direction, is thus wasted.

The complex nature of the quadriceps muscles makes it impossible to accurately measure this loss of force resulting from a less than perfect direction of pull . . . but it would be reasonable to assume that at least 20 percent of the force actually produced by the muscle is wasted by this factor; which means that we must add 25 percent to make up for the lost force, or must subtract 20 percent as an additional loss from the output of functional force.

Meaning that the actual output of measurable functional force in the above example would be only 8 pounds . . . an input of 120 pounds by the muscle but an output of only 8 pounds at twelve inches below the axis of the knee, or an output of only a bit more than 5 pounds if measured at the foot.

All of which applies only during a dynamic situation, when the muscle is contracting and the lower leg is moving towards extension; because there is no loss of strength from friction during a static test of strength. In a static situation, when the muscle was producing the same force but the lower leg was not moving, then the measured output of functional strength would be about 20 percent higher than indicated above.

Or, in a dynamic test of negative strength . . . then the measured output of functional force would be 40 percent higher than that produced during a test of positive dynamic strength; because the friction in the muscle helps you during negative work. Hurts you during positive work, helps you to the same degree during negative work, but neither helps nor hurts during static efforts.

Friction in a muscle?

Yes . . . everything in nature produces friction, if it is moving, and a muscle must produce internal movement in order to contract.

Even light produces friction . . . and the power in an average car is reduced approximately 70 percent by friction. So don't be surprised that a slowly contracting muscle loses about 16 percent of its force due to friction. That is not a high degree of friction; on the contrary is a very efficient situation.

Movement of anything produces friction . . . and, once moving as a result of an applied force, an object will then accelerate until the friction produced by movement is equal to the applied force.

Then how can Cybex Corporation claim that a higher level of functional force (strength) can be produced in a dynamic test than the force measured in a static test?

Because they are not measuring functional strength . . . instead are measuring the high and dangerous levels of impact forces produced when the subject crashes into the resistance pad. Impact forces that distort and magnify the actual force produced by the muscle by several hundred percent. Levels of functional force that cannot be produced by the muscles, but that are imposed on the joints of the subject by impact loading. Try pushing against a boulder with you foot, and then kick it as hard as possible. You will actually produce more functional force while pushing, but will be exposed to far higher and very dangerous forces when kicking.

If your positive strength, your lifting strength, is 100 . . . then your static strength will be 120, and your negative strength will be 140; these ratios being true only during tests performed at relatively low speeds during the dynamic tests . . . greater differences being produced at higher speeds because the friction in the muscle is increased at higher speeds.

But regardless of the speed, and regardless of the level of either strength or fatigue, the static strength will always be exactly midway between the positive and negative levels of strength . . . because the static level of strength is the actual level of strength, unbiased by friction within the muscle. While positive strength is reduced by muscular friction and negative strength is increased by muscular friction.

Because of the many factors outlined above, the quadriceps muscles are required to produce enormous levels of force in order to produce an output of functional strength that is required for even normal activities; a very strong man, in order to produce a measured output of 600 foot-pounds of torque with his quadriceps muscles, and some few men can . . . is thus required to produce a force in excess of 7,000 pounds of pulling force with his quadriceps muscles; which exposes his knees and femurs to an even higher level of force, a far higher level of force . . . 73 percent higher if his legs are bent 120 degrees at the time this force is produced . . . but only a little over 40 percent if the legs are bent 90 degrees . . . and only about 9 percent if the legs are bent 66 degrees.

This increase in compression forces on the knees and other parts of the body results from the fact that the structure of the legs above and below the knees creates a block and tackle situation when the legs are bent at the knees. Meaning that a force of 7,000 pounds produced by the quadriceps will be increased to a level of compression force on the knees in excess of 12,110 pounds if the legs are bent 120 degrees at the time.

But if the legs are straightened to a point where they are only 66 degrees short of full extension, then this magnification of compression forces is reduced to only 9 percent . . . when fully extended, straight, the magnification of force is zero.

Yet many doctors and therapists are still telling people with knee injuries to avoid exercise within the last twenty or thirty degrees of extension . . . under the totally mistaken impression that working in that area of movement imposes high levels of compression forces on the knee; when, in fact, quite the opposite is true. Which should be obvious, since the required mathematics is at about a third-grade, grammar-school level, and the required physics at about a first year of high school level; unless they have changed the laws of physics and the rules of math since I learned them more than half a century ago, or perhaps some people fail to realize that physiology simply means the physics of biology.

Now you should also realize just why knee problems are so common, and why things like jump squats are so dangerous; and why the lumbar spine is so much more efficient than the knees.

A recently published article on the subject of the proper style of lifting reached the correct conclusion, but for the wrong reason; the author suggested lifting with a lordotic curve, rather than a pelvic tilt. His reason being that the muscles of the lumbar are strongest in lordosis, and thus less likely to be injured . . . a statement that is partly true and partly false. In fact, the lumbar is not stronger in a lordotic curve . . . but is less likely to be injured if lifting is done in the manner suggested. Lordosis being safer because the muscles are not stretched to their limits, and if forward movement is forced then the muscles are capable of such movement without being injured.

This author stated that recent tests of the actual strength of the lumbar muscles had proven that these muscles are actually far stronger than was previously believed. But the facts are that he has never seen, nor even heard of, any tool of any sort that was capable of producing measurements of lumbar strength. The only equipment in the world that is capable of making such measurements in anything even approaching a meaningful manner is not yet available to anybody outside a limited number of researchers.

Equipment that is capable of measuring lumbar strength with an accuracy approaching 100 percent now exists . . . but nothing on the subject of this equipment was published prior to August of 1987, and thus was not available to this author.

Published and advertised claims made on behalf of isokinetic methods of attempting to measure lumbar strength are utterly ridiculous . . . would perhaps be amusing if they were not being accepted by some people who remain unaware of the facts . . . and if the suggested methodology of testing was at least safe.

But the facts are that the results of all such tests are worse than worthless, worse because they are grossly misleading . . . and the method employed for conducting such tests is dangerous to an extreme degree. Danger to no purpose. Danger with no slightest chance of worthwhile return.

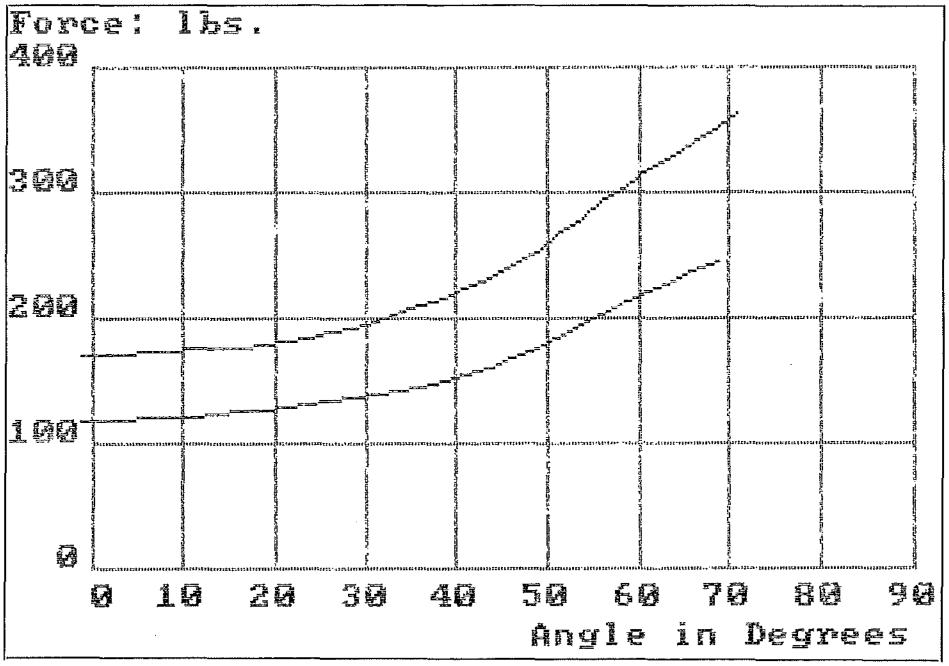


FIGURE 14: A measurement of the output of force (torque) that is produced by a maximal muscular contraction can be very misleading if you fail to consider the involvement of at least one important factor . . . the joint system of the body, and thus the advantage or disadvantage of leverage that a muscle must use in performing work.

When comparing the relative strength of the lumbar-extension muscles, for example, to the leg-extension muscles, the quadriceps . . . it might appear that the lumbar muscles are nearly as strong as the big muscles of the thigh; when in fact nothing could be further from the truth.

The lumbar muscles are perhaps the most efficient muscles in the body; but still are not very big, and thus are not really very strong. Meaning . . . the muscle itself cannot produce an actually high level of force. Only appears to do so because of an advantage of leverage. But remember, ten pounds of force will lift a ton .... if you use a long enough lever. Will not lift it very far, but will lift it. Also remember that the lumbar muscles are not required to move the vertebra of the lumbar very far, while the thigh muscles must move the lower legs a relatively much greater distance.

So don't make the mistake of trying to compare the lifting strength of two men . . . one of whom is using a long crowbar and one of whom is not. Which is similar to what you are doing when you compare the measured output of the lumbar to that of the thighs.

Also note that the peak of strength was not produced in the position of normal lordosis, as incorrectly stated in the previously mentioned article; rather, the peak of strength was in the starting position, when the lumbar spine was straight. By the time the subject had moved back to a position of normal lordosis, the level of strength had declined by about a third from its level in the starting position . . . a very meaningful drop in strength, not an increase as stated in the article.

The right side of this chart shows strength in the forward position, when the lumbar spine is straight . . . the left side of the chart shows strength in the fully-extended position, when the spine is bent to the rear.

Such a test can be started at the limits of the front position, but must be stopped short of the fully-extended position; because the output of force in the extreme rear position will always be zero . . . in that position there can be no measurable output. Regardless of how weak or how strong you are, your measurable output of force will always be zero at the limit of the possible range of movement produced by muscular force. And since a reading of zero gives us nothing for comparison to later tests, we must stop testing before we reach that point in the movement.

We perform exercise in the last few degrees of the range of movement, but we cannot test there with a meaningful result.

Also note that there are two curves on the chart; the highest curve being an accurate measurement of the strength of the fresh muscles; the second, lower curve being a measurement of the lumbar strength immediately after an exercise for these muscles. So these are pre-exercise and post-exercise tests . . . the difference being an accurate measurement of the effect of the exercise, the immediate consequences of the exercise . . . clearly showing just how much his strength was momentarily reduced by the exercise, and where it was reduced.

The average loss of strength throughout the tested range of movement was approximately thirty-one percent . . . this being based upon the change in the areas under the curves. This subject produced this effect by exercising for thirteen repetitions while using resistance of 200 foot-pounds, and by continuing the exercise until additional movement was momentarily impossible.

Meaning that when he failed, his remaining strength was slightly below the level of resistance.

This degree of effect, a thirty-one percent loss in strength, is on the high side for good results. Better results will generally be produced when the degree of effect of exercise is limited to about twenty percent . . . at least fifteen percent and not more than twenty-five percent.

But such a degree of effect cannot be produced by guesswork; tests such as this, however, will clearly tell you just how much resistance, and how many repetitions with that resistance, are required for the desired degree of effect from exercise.

This subject, as judged by this test result, requires a somewhat higher level of resistance . . . which higher resistance will automatically produce the desired degree of effect very accurately.

When proper exercise for the lumbar muscles is performed, and when it is proper in every sense, it is not only very safe but very productive; and rapid increases in strength will be produced . . . but very little in the way of exercise is actually required to produce good results, and more will seldom produce better results, will usually produce less results.

Confusing back-extension with lumbar function has created a great deal of misunderstanding. While it is certainly true that lumbar function is usually involved in back extension . . . usually, but not always . . . it is also true that back extension is largely a result of the muscles that move the pelvis in relation to the legs, primarily the muscles of the buttocks and the thigh-biceps muscles.

Until and unless these muscles are totally removed from the equation, it is simply impossible to measure the strength of the lumbar muscles. The muscles of the buttocks, working with the thigh-biceps muscles, move the pelvis in relation to the legs . . . and such movement is usually a part of back extension; but this movement has absolutely nothing to do with lumbar function . . . in fact, this movement is usually the source of the problem in the first place. Damage to the lumbar muscles is usually a result of the forces produced by these other, larger and far stronger, muscles . . . and when a very high level of force is produced by these muscles, a high level of force that exceeds the limits of the structural integrity of the lumbar muscles, then an injury becomes a certain result.

The strength of the lumbar muscles is not very great . . . in fact, the lumbar muscles are the weak link in the system.

All previous attempts to determine the strength of the lumbar muscles have failed because, until recently, it was simply impossible to test the strength of these muscles in total isolation. Total isolation of the lumbar muscles, and thus the possibility of accurate measurement of lumbar strength, was first made possible less than two years ago . . . but not in a practical manner.

The machine that first made such accurate testing possible was huge, very complex, uncomfortable for a healthy subject and all but impossible to use with an injured subject, and intimidating for any subject . . . but it did, at least, provide the first source of accurate measurement of lumbar function. It was capable of producing accurate tests of lumbar function, and nothing else was, but it certainly was not practical for anything more than very limited use in a research environment. But that situation now has changed.

The key to accurate testing of any muscle is isolation, which in many cases is impossible; fortunately, in the case of the lumbar muscles, the required degree of isolation did prove to be possible. Not simple, but possible; we worked on this situation for more than fourteen years before we even understood the problems that had to be solved. Providing practical solutions for these problems took an additional amount of time and an enormous amount of work. While you may or may not be interested in exactly how and why something works, or why something does not work, in this instance it is very important to understand both the problems and the solutions to those problems; thus, in more than one sense of the term, this book largely consists of a how-to manual . . . how to test the lumbar, how to rehabilitate at least some of the common lumbar problems, and how to design and build a meaningful testing machine for the lumbar.

Without such an understanding, some people will be left in doubt and many of the mistakes of the past will be repeated; but given the information in the following chapters, such doubts should be resolved . . . so do not make the mistake of skimming over the following chapters, perhaps under the impression that technical details are of no practical value. While it may be true that the safe use of a car does not require the knowledge necessary for building a car, in dealing with lumbar problems you must understand both the problems and the solutions . . . the methods detailed for meaningful testing of lumbar function that are described in later sections of this book are not merely one of the best methods for this purpose, they are quite simply the only method for meaningful testing. There is no other way.

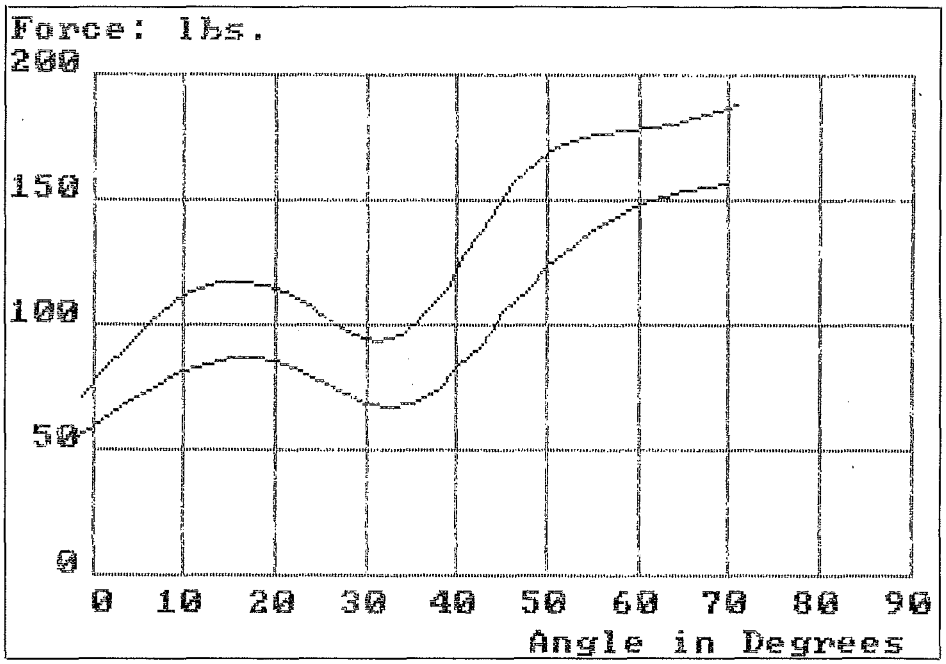


FIGURE 15: **This chart illustrates two strength tests of a subject with a previously unsuspected lumbar problem. The higher of the two curves is a full-range test of his fresh strength, while the lower curve is a full-range test of his momentary strength immediately following an exercise for the lumbar-extension muscles. Thus this chart represents both pre-exercise and post-exercise lumbar strength. Lumbar strength tested in total isolation, with no slightest involvement of other muscles.**

The differences in these two test results are an accurate measurement of the effect of the exercise, the immediate consequences of the exercise, the momentary reduction in strength resulting from the exercise. This degree of effect was produced by exercising for thirteen repetitions with a resistance of 150 foot-pounds.

The subject is a white male, 31 years of age, five feet ten inches tall and weighing 160 pounds; with no history of lumbar problems and totally asymptomatic.

A later series of three lateral x-ray pictures with the lumbar flexed, lordotic and extended produced no additional evidence of pathology; but with or without such additional evidence, this subject has a serious problem in his lumbar . . . almost certainly a problem related to the soft tissue.

A follow-up series of CAT-scans and magnetic resonance examinations is scheduled but the results of these tests are not yet available. But again, with or without such additional evidence, this subject has a problem; a problem that was immediately identified by a proper testing procedure of lumbar function.

Apart from the marked dip in strength that occurred in a position about thirty-three degrees short of full extension, this subject's lumbar strength curve was normal; but such a dip in strength is not normal, is clearly indicative of a problem. A problem that would not have been identified by a dynamic test.

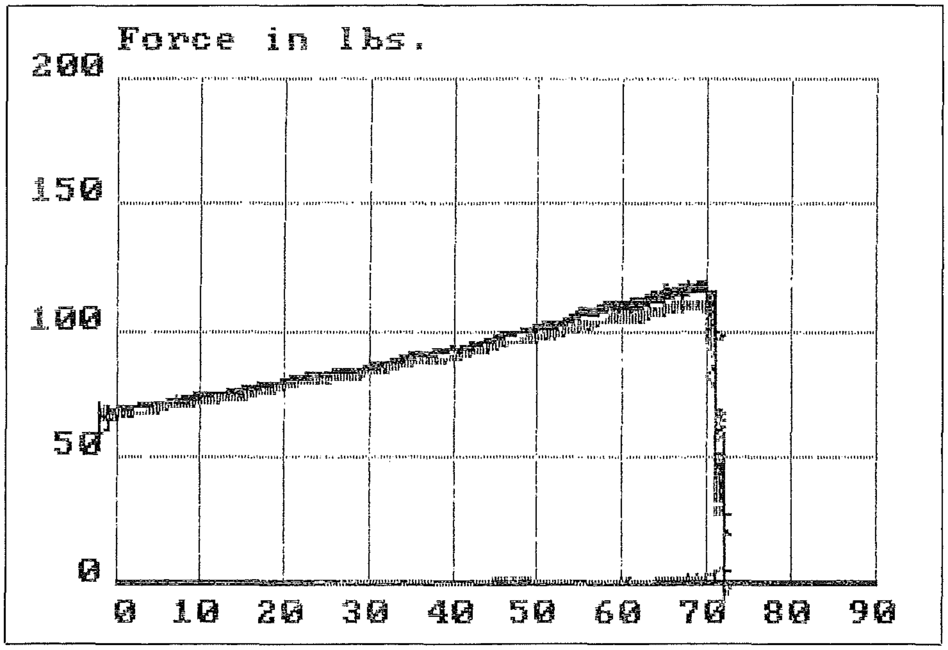


FIGURE 16: This chart shows the forces produced during a dynamic test of the same subject. The speed of movement varied from a high of about 80 degrees per second during the first repetition to a low of below 20 degrees per second during the final repetition. Resistance provided during the entire range of movement of 72 degrees was 150 foot-pounds; with which resistance this subject was able to perform 13 repetitions before failing.

There are a total of twenty-six force lines on this chart; one line for each of the thirteen positive (lifting) movements and one line for each of the thirteen negative (lowering) movements.

At the point where the desired level of resistance was exactly 100 pounds, the total variation in actual force was only five and one half pounds . . . meaning that the force imposed in that position was never more than two and three-quarters percent above or below the desired level of force.

Since the friction in this machine adds about one percent to the resistance during the lifting part of the movement while subtracting about one percent from the resistance during the lowering part of the movement, this means that this subject produced an additional variation of force of only about one and three-quarters percent as a result of kinetic energy and his own inability to produce a perfectly smooth movement.

Which figures are conservative, because these figures were based on this published chart rather than the raw data, and this chart shows its force curves on a gross scale.

Thus the actual variation in the forces was even less than shown . . . ideally will be, and can be, less than one percent.

Compared to the wildly varying levels of force produced in any sort of isokinetic testing or exercise machine, the level of resistance provided by this machine is almost perfect; a near perfectly controlled level of force produced by the fact that eighty-seven and one-half percent of the kinetic energy has been engineered out of this machine . . . making it possible to move at relatively fast speeds without suffering the consequences of wildly varying force levels and high levels of impact forces that are unavoidable in isokinetic machines.

This subject experienced no pain or discomfort during either of the two static strength tests and was able to conduct the dynamic test with no pain or discomfort; but if he had been tested only in a dynamic fashion then there would have been no indication of his strength-curve abnormality, and thus his lumbar problem would have been overlooked.

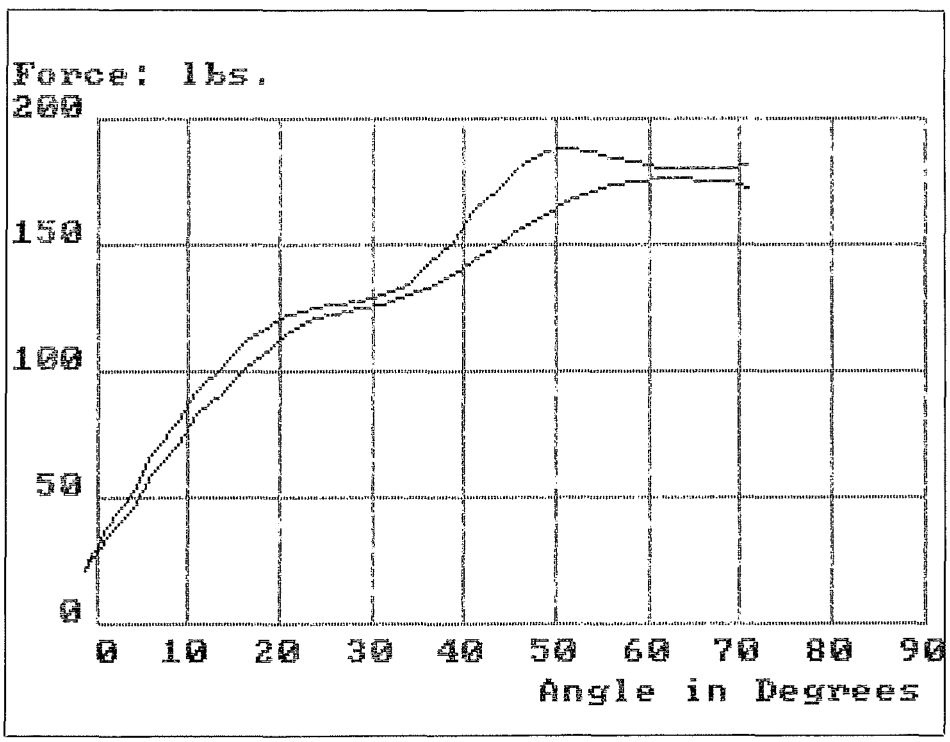
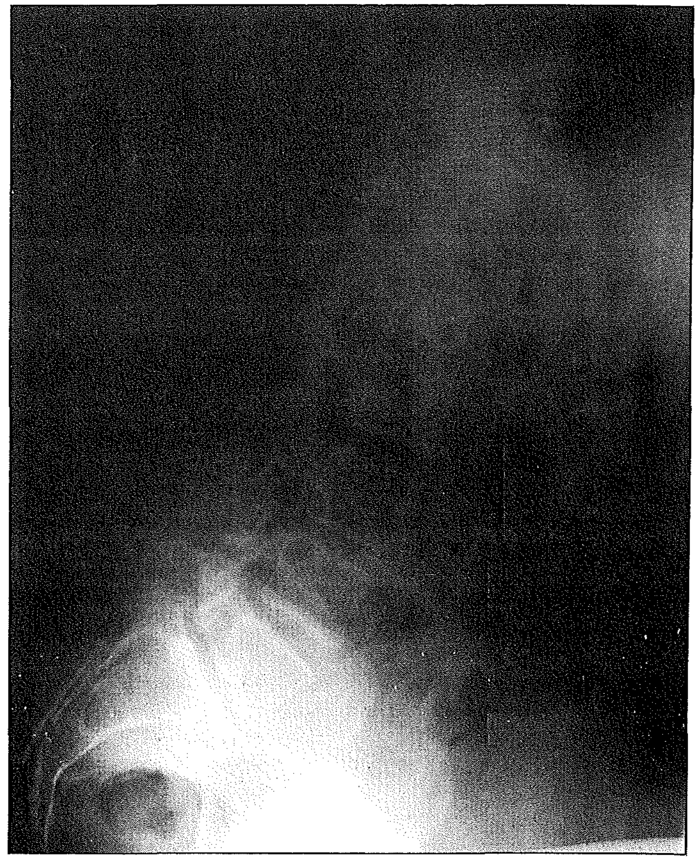


FIGURE 17: This chart represents the lumbar test results of a retired physician, 70 years of age, a white male of five feet and six inches weighing approximately 150 pounds; this subject was born with an abnormal lumbar spine, L5 being located to the front of a normal position in relation to the sacrum . . . but in proper relation to the other lumbar vertebra. These abnormalities are clearly shown in following illustrations.

In this instance, the subject is asymptomatic at present but did have lumbar pain many years earlier. His strength level is normal for his size and age but his strength curve is abnormal in two respects; in the starting position of the tests, when his spine was flexed, he should have been somewhat stronger . . . instead of rising or remaining constant, his strength should have declined as extension occurred. Secondly, later in the range of movement, his strength showed a slight dip at one point; nothing on the order of the drop in strength displayed by the other subject, but a dip in strength that should not have occurred.



FIGURES 18, 19, & 20: **The genetic abnormality of this subject's spine produced a limited range of movement in the direction of lumbar flexion and eventually resulted in lumbar pain; a condition that might have been detected much earlier had it then been possible to conduct meaningful tests of lumbar function.**

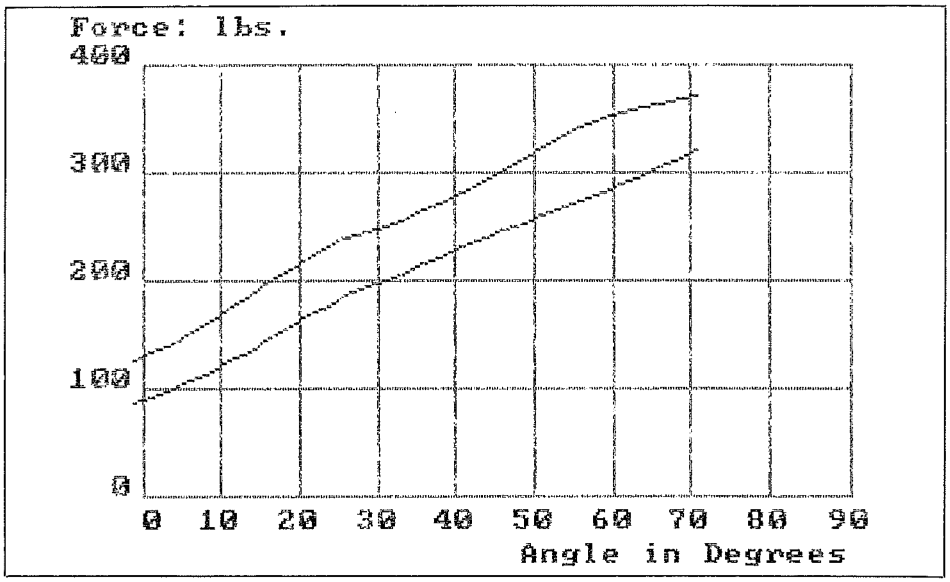


FIGURE 21: The above chart compares the results of two tests of isolated lumbar strength throughout a full range of normal movement. The higher curve representing the fresh strength of the lumbar-extension muscles prior to an exercise for these muscles. The lower curve representing the lumbar strength immediately after the exercise. The differences between these two recorded levels of strength being the effect of the exercise, the immediate consequence of the exercise.

Both curves are perfectly normal, indicating proportionate and appropriate levels of strength in every position.

But other important information is provided by these tests as well; one, the level of strength is well above average for a subject of this age, size and previous exercise experience . . . two, this is obviously a Type S subject, meaning that he responds to exercise in a specific manner, will produce results only in positions where exercise is performed, this being obvious because of the relationship of his strength in his strongest position to that in his weakest position . . . three, this subject shows a mixture of fiber types in his lumbar muscles, this determination being based upon the magnitude of effect produced by the exercise.

Nine repetitions of a full-range exercise for the totally isolated lumbar muscles produced a momentary reduction in strength of 20.28 percent; this effect of the exercise, the immediate consequence of the exercise, being based upon the changes produced in the areas under the curves.

This tells us several things. Tells us that he has an average distribution of fiber types in his lumbar muscles. Tells us that he should exercise with the level of resistance used during this test, because the degree of effect was appropriate for producing good results from exercise. Tells us the existing ratio between his strength and his anaerobic endurance; which means that we will never again have to measure his strength in order to know his strength . . . because, once the ratio of strength to anaerobic endurance is established, then later measurements of anaerobic endurance will also tell us his strength, since strength and anaerobic endurance go up and down together.

Future increases in his anaerobic endurance will clearly tell us that his strength has increased in exact proportion. Which adds to the safety of later tests, because tests of anaerobic endurance can be conducted at lower levels of force. And the lower the level of force, the higher the level of safety.

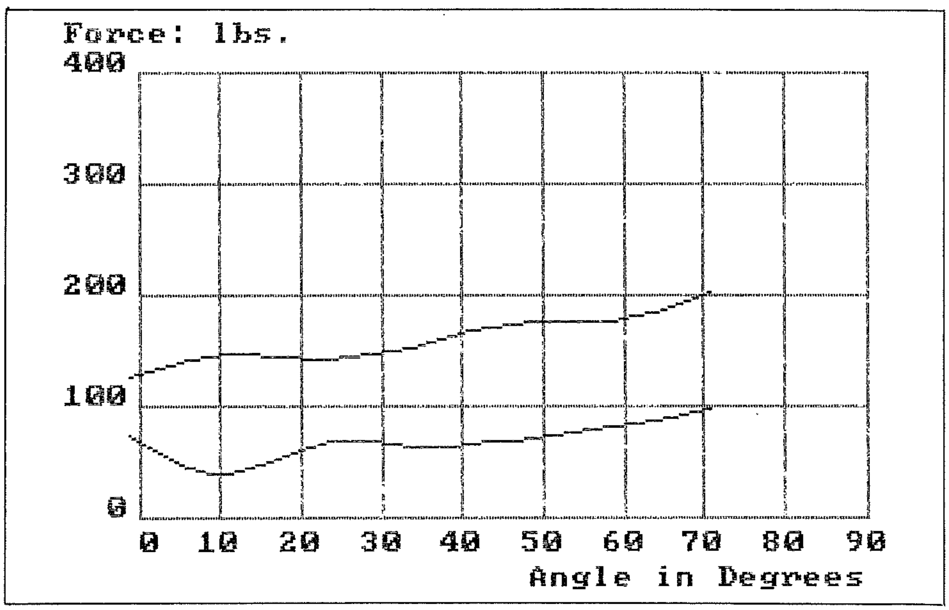


FIGURE 22: This chart shows the pre-exercise and post-exercise strength tests of totally isolated lumbar-extension muscles in a different type of subject . . . a different fiber type.

This subject produced an effect, a temporary loss of strength, of nearly 57 percent from an exercise performed for ten repetitions using 100 foot-pounds of resistance. Nearly three times the degree of effect produced by the previous subject.

Which is far too high a degree of effect for good results from exercise. Best results from exercise will generally be produced by an effect somewhere between 15 and 25 percent.

Which means that this subject must be exercised very carefully . . . not too much and not too often. Which also means that he has an unusually high percentage of so-called fast-twitch muscle fibers . . . close to 100 percent from the results of this test. Meaning that he has a very high potential for strength in these muscles, but will never have much endurance.

Since his tested strength level was only average, this means that he has performed little if anything in the way of meaningful exercise for these muscles; because, given this type of muscle fibers, he has great potential for lumbar strength.

The shape of his strength curve, the ratio of strength in his strongest position to that in his weakest position, tells us that he is a Type G subject . . . meaning that he will respond to limited-range activity in an overall manner. Will produce full-range strength increases even from limited-range exercise . . . which is a decided advantage since most activities are limited-range in nature. Most subjects are Type S (specific), while about 18 percent of the subjects that we have tested proved to be Type G (general).

So we have a good example of a typical Type G subject with an unusually high percentage of fast-twitch muscle fibers. Compare this subject's test results to the following chart.

FIGURE 23: This chart presents the pre-exercise and post-exercise test results of totally isolated lumbar strength in a subject who is different from the preceding subject in two important ways.

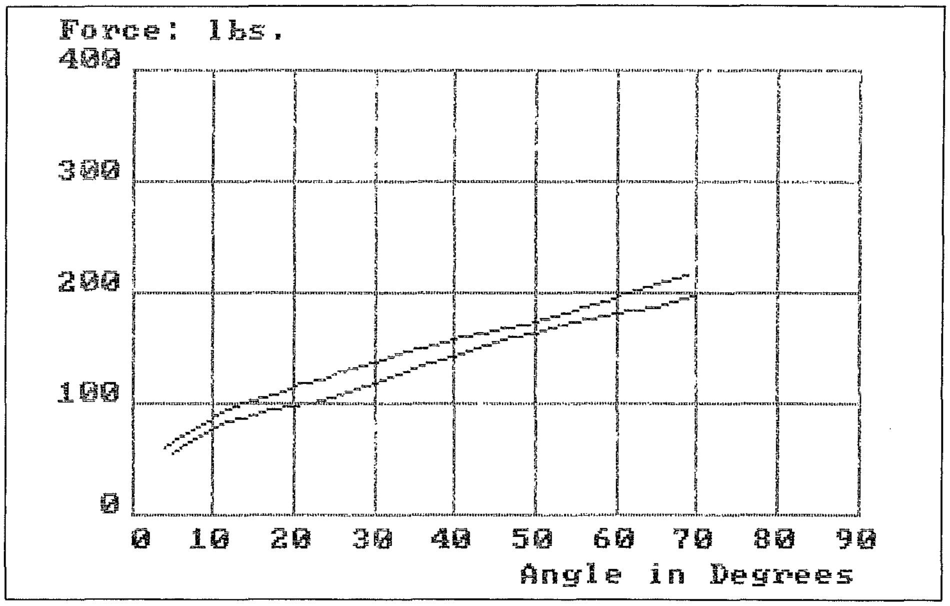
This is a Type S subject. . . his strength in his weakest position is far lower as a percent of his strength in his strongest position, by comparison to the earlier subject. In their strongest positions, the strength of these two subjects was almost exactly the same; but in the weakest positions, the Type G subject was more than twice as strong as the other subject.

In fact, the situation was even more radical. . . because their range of possible movement was not the same in the direction of extension. The Type G subject was far more flexible, demonstrated a greater range of movement towards extension.

If the Type S subject had an equal degree of flexibility, then his strength in the extended end of the movement would have been even lower than shown here. So a true comparison of strength in the extended positions would be about a three to one ratio . . . meaning that the Type G was three times as strong in that position although no stronger in a flexed position.

Which comparison demonstrates the importance of correlating accurate measurements of position with measurements of strength. A test of peak strength with these two subjects would have indicated an equality in strength when in fact that is not a true picture.

But there is another difference of far greater importance; this subject probably has almost 100 percent slow-twitch fibers in his lumbar muscles, the opposite type of fiber shown by the earlier subject.



In this case, the higher of the two strength curves is not the pre-exercise test; instead, it is the post-exercise test. The exercise did nothing to reduce this subject's starting level of strength, actually increased the starting level of strength.

During the test we gave this subject a level of resistance that was a bit too low and he proceeded to perform a seemingly endless number of repetitions; eventually I told him to stop, since the resistance was obviously too low, and then we tested his post-exercise strength immediately. With the results shown; his strength had increased throughout the full range of possible movement, increased by 10.31 percent based upon the areas under the curves.

Later, when given a somewhat higher level of resistance, this subject did continue the exercise to a point of momentary failure; but even then the degree of effect was very low. His strength was reduced by only about two percent from its starting level.

Such a subject will never be very strong in his lumbar muscles, but will display an almost unbelievable level of anaerobic endurance.

But the important thing to realize is that a style of exercise that is actually required by this subject would be utterly devastating for the other type of subject. This subject requires high-repetition exercise; the other subject cannot tolerate high-repetition exercise, would rapidly lose strength if worked in that manner.

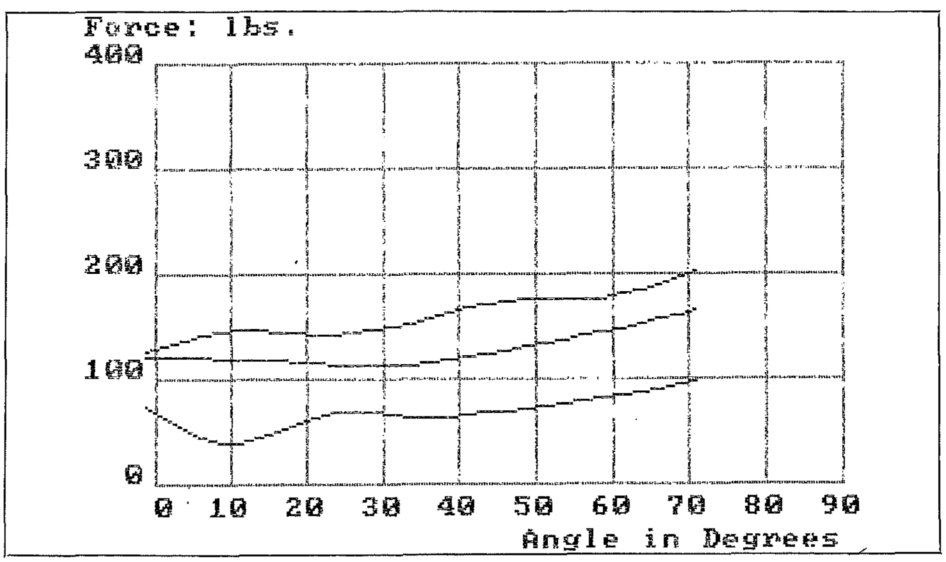


FIGURE 24: This chart shows three strength tests with the Type G subject shown earlier. The same two pre-exercise and post-exercise tests and a third test, a test performed two hours and forty-six minutes after the post-exercise test; a recovery test.

This third test is performed and compared to the other two tests in order to determine just how quickly the subject is recovering from the effects of the exercise . . . which tells us a great deal about his recovery ability, and thus his tolerance for exercise.

In this case, after nearly three hours, the subject had recovered just over sixty-six percent of the loss in strength produced by the exercise; which is a very slow rate of recovery, and does not mean that he will be totally recovered within another two or three hours.

Initial recovery is very rapid, and in most cases a normal subject will recover fifty percent of the lost strength within about thirty minutes; but then it will take him another twenty-four hours or more to recover completely.

When the degree of recovery shown here is factored by the time required to produce it, this means that total recovery will require at least two days, and probably three days. If this subject, or any subject, is exercised again before total recovery has been produced, then the result will be a loss in strength rather than a gain.

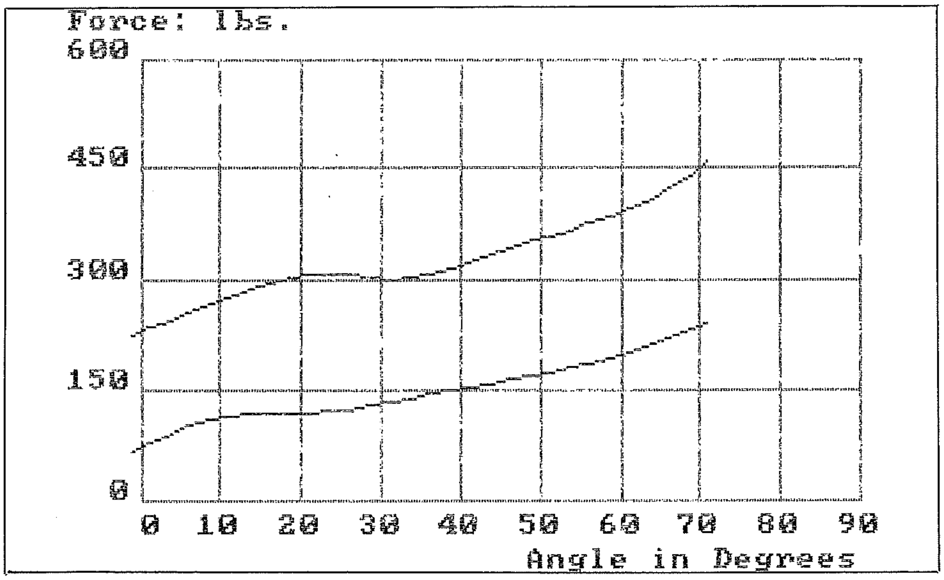


FIGURE 25: **This chart shows the pre-exercise and post-exercise tests of another subject with an average distribution of fiber types. Another Type S subject with an average level of strength for his age, size and previous history of exercise.**

The degree of effect from the exercise was slightly on the high side for best results but this can be corrected by adding a small amount of resistance.

Range of movement was unrestricted in either direction, the total range of possible movement being 73 degrees.

The only thing not quite right is the fact that a very slight dip occurred in the pre-exercise test of fresh strength . . . but since no such dip occurred in the post-exercise test, then it is almost certain that the slight dip resulted because this subject really did not try quite as hard as possible in that one position during the initial test.

Which could have been confirmed or refuted by asking him to repeat the pre-exercise test prior to any exercise. If such a shape in the tested strength curve is indicative of an actual decline in strength in that position, then it will repeat itself in two tests performed a few minutes apart with no exercise between. Assuming only that the subject cooperates in both tests.

An exception to this general rule occurs with subjects that have an unusually high percentage of fast-twitch muscle fibers; such subjects will display a much lower level of strength in a second test, even without exercise between the two tests, because they suffer from fatigue as a consequence of their fiber types. But even then, while the tested levels of strength will be different with such subjects, the shape of the strength curves will not change and any abnormality in shape will repeat itself.

NOTE . . . The charts on this page were accidently reversed by the printer, when reading the caption for figure 25, look at figure 26, and when reading the caption for figure 26, look at figure 25.

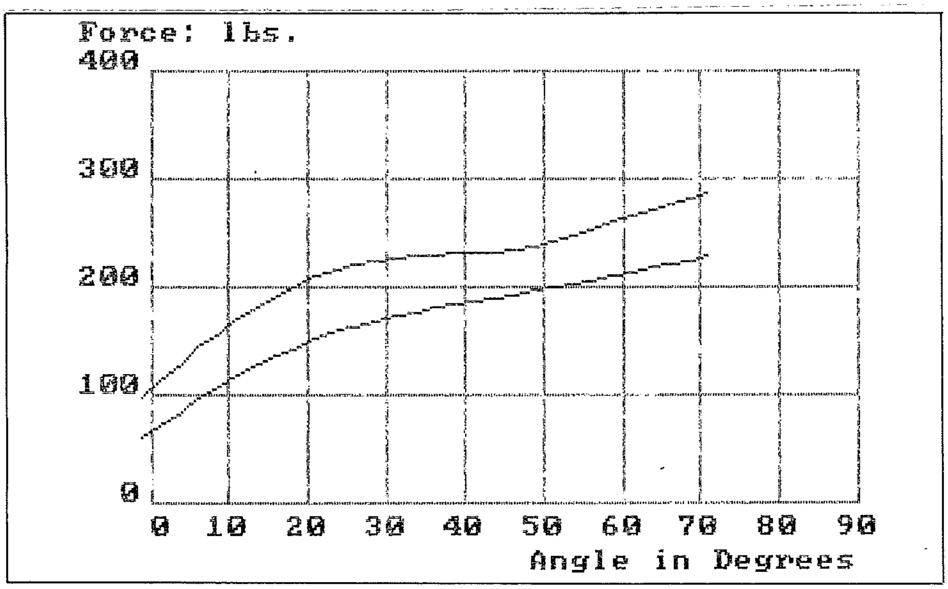


FIGURE 26: **This chart combines the pre-exercise and post-exercise strength-test results of totally isolated lumbar-extension muscles in a subject with an unusually high percentage of fast-twitch muscle fibers. An effects test, showing the immediate consequence of the exercise.**

This subject produced this effect as a consequence of only six repetitions with a resistance of 200 foot-pounds . . . a momentary reduction in his starting level of strength of just under 55 percent. A very deep effect.

The relatively flat strength curve in his fresh muscles also tells us that he is a Type G subject, will produce full-range results even from limited-range activity or exercise; his strength in his strongest position was only about twice the level in his weakest position. A Type S subject would show a much greater loss of strength in the extended positions.

Such an effect, a momentary loss of strength exceeding nine percent per repetition, is far too much for good results from exercise; if trained in this manner too often, the result would be a loss in strength rather than an increase. Such a subject should never be exercised more than twice a week, and may produce better results on a schedule of only once a week.

But such comparisons tell us other things of enormous value . . . clearly spell out just what type of work this subject can handle without risk of injury; and of perhaps greater importance, the type of work he should avoid.

This subject is very strong in his lumbar-extension muscles, but has very little endurance . . . can easily and safely handle heavy lifting, if such work is not repeated too often . . . but must not perform work that requires either frequent or continuous lifting. Not even frequent lifting of a relatively light weight.

A high percentage of injuries to the soft tissue of the lumbar area are caused by fatigue; but a fatigued muscle does not lose its structural integrity, remains as structurally strong as it was when rested . . . that isn't the problem. What happens is that fatigue causes the worker to change his style of lifting, and that change in procedure is what causes the injury; either from the addition of force produced by jerking instead of lifting, or from lifting in an unusual posture. A position that imposes the force in an area of the body that cannot tolerate the load.

Based upon his demonstrated level of lumbar-extension strength, far above

average . . . it might appear that the above subject was ideally suited to a job that involved lifting; while, in fact, quite the opposite is true.

Given that level of lumbar strength, and given an entirely different type of muscle fiber, then he would be suited for such work. But such a combination is rare, this being a classic example of an either/or situation; you can have a strong back as a result of your fiber type, or you can have great endurance in your lumbar muscles, but not both. Most people are neither; instead show a mixture of fiber types that preclude great strength but give them a reasonable level of endurance.

Employed in a position that involved frequent lifting, even rather light lifting, the above subject would fatigue very rapidly. Then in order to continue working he would be forced to change his style of lifting, thereby greatly increasing the chance of injury.

Another subject mentioned earlier, the subject with an abnormal level of endurance, would be ideal for such employment; while less than half as strong as this subject, he could work continuously with little or no sign of fatigue. Would not be forced by fatigue to change his style of lifting, and would thus be far less likely to sustain an injury. While nowhere near as strong as this subject, the man with the endurance type muscle fibers in his lumbar muscles has a far higher level of work capacity.

Given the requirement to lift a weight of 50 pounds once every two minutes, the stronger of these two subjects might be flat on his face within an hour or two; while the weaker of the two could work ten or twelve hours in an almost nonstop fashion, and might be stronger at the end of the day than he was at the start.

The strength of both men can be increased by proper exercise, and doing so will increase their anaerobic endurance in direct proportion; but even if given an increase of fifty percent in his endurance, the stronger man would still have very little . . . and given an increase of fifty percent in his strength, the other man would still not be very strong.

Both subjects should be exercised, and both stand to gain from exercise, and proper exercise for the lumbar muscles will reduce the chances of injury in both cases . . . but it will not change the type of muscle fiber they have.

The implications should be obvious for industry; as a screening test for workers, such tests can go a long way in the direction of fitting the job to the man. The annual cost of lumbar injuries being what it now is, even a slight reduction in the number of such injuries would quickly justify the costs of conducting these tests with all or most of the workers in many occupations.

By the end of this year, 1987, we should have completed accurate lumbar testing on a total of at least 30,000 subjects; which test results will be published in a supplement to this book to be prepared in December of 1987 and published in time to be distributed simultaneously with the publication of this book in late January of 1988.

These tests are being conducted at the University of Florida School of Medicine in Gainesville and in three other locations; under the direct supervision of Dr. Mike Pollock, past president of the American College of Sports Medicine, and other equally qualified people, several of whom are orthopedic surgeons. During 1988 we intend to conduct at least an additional 100,000 lumbar tests; all of which will be included in later supplements to this book.

But it is already apparent from the tests that have been conducted up to date that lumbar function is far different from most previous assumptions . . . and equally apparent that earlier attempts to measure lumbar function were meaningless.

We already have an enormous amount of data, and from a careful study of this data have reached a number of unavoidable conclusions . . . the evidence is simply overwhelming; even though a few of these conclusions are direct refutations of beliefs that some people simply take for granted.

But in one sense at least, it was probably an unavoidable situation, certainly an understandable situation . . . because, before meaningful testing became a reality, all of us were guessing, basing our opinions on data that was misleading.

Lumbar function is very complex, can be tested in a meaningful manner only under carefully controlled circumstances using equipment that provides all of the essential requirements; none of which requirements were provided in any of the previous equipment intended for this purpose. Most of which requirements cannot be provided by any form of isokinetic testing machine.

Now that we can test lumbar function accurately and in a meaningful manner, it is only a matter of time until many of the presently misunderstood problems in this important area of the body will be understood; when we finally do understand the problems, perhaps we will also have a better understanding of how to deal with them.