The Future of Exercise
(1997 and Beyond)

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Some Very Basic Physics

Much earlier in the 20th century, somebody asked Thomas Edison what he thought of Einstein's theory of relativity; to which he replied . . . "I don't think anything about it, because I don't understand it."

Even today, the vast majority of people still do not understand it, but a few people who did understand it developed atomic power, and changed the world forever. In the field of exercise physiology, very few people understand the basic laws of physics that are involved in muscular function, and most of the supposed "experts" in the field not only do not understand the physical laws of muscular function but are not even aware of them.

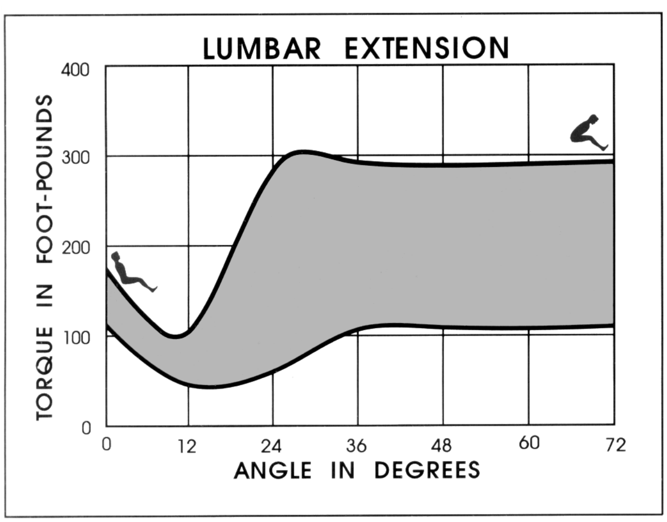
Exercise is usually performed for only one reason: in order to stimulate changes in some parts of the body that will produce improvements in functional ability; although many bodybuilders are exceptions to that general rule, seem to be interested only in their appearance, with little or no regard for functional ability.

But regardless of your reason for performing exercise, it helps if you are at least aware of just what results are possible, and how to proceed in order to produce those results. It also helps if you understand which results are impossible to produce; knowledge that should at least help you to avoid a lot if wasted efforts. Muscular atrophy, a reduction in both muscular size and strength, will usually result from one of only two things: a total lack of exercise will result in "disuse atrophy," while too much exercise will produce "overuse atrophy," with almost identical results in either case.

As they say . . . "If you don't use it you will lose it." A saying that is usually true; but you will also lose it if you use it too much. But you cannot evaluate the results of any exercise program until you can accurately measure the physiological changes that are stimulated by your exercise. But meaningful measurement of functional ability, or changes in functional ability, was impossible prior to 1987; until then, we had neither the required knowledge nor the necessary tools.

Even without such knowledge, certain trends were obvious: if your muscular size was increasing, or if you could lift more weight than you could previously, providing only that the style of lifting and the speed of movement remained identical in both cases, then you were producing improvements. But you could only guess about the degree of change, and usually did not even know which muscles were becoming stronger; that last statement being true because most movements involve contributions of muscular force of contraction from several different muscles. While most people still believe that exercising by extending your back against resistance will increase the strength of lower-back muscles, we now know that such exercise will do little or nothing in the way of increasing lower-back strength, the actual work is performed by the muscles of the hips and thighs; and while the lower back certainly moves during such exercises, this movement is not produced by the lower-back muscles.

fig. 1

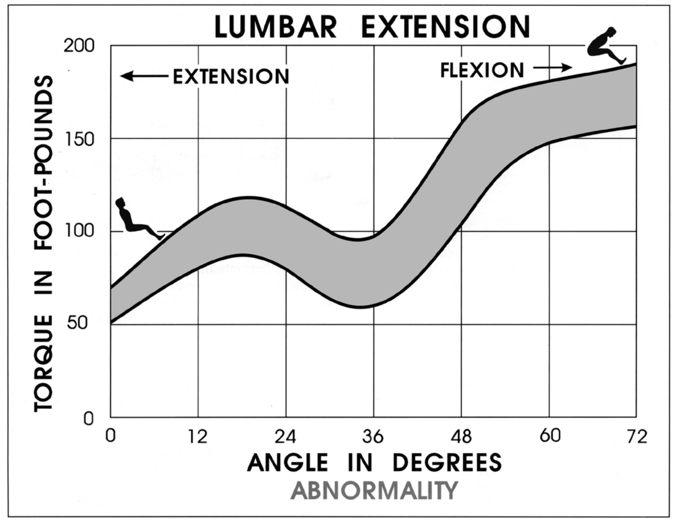


So any resulting increases in your ability to perform such movements against higher levels of resistance does not mean that your lower-back muscles are becoming stronger. Any such improvement usually means, instead, that your hip and thigh muscles are becoming stronger.

In October of 1987, during the course of a medical meeting in New York City, "The Challenge of the

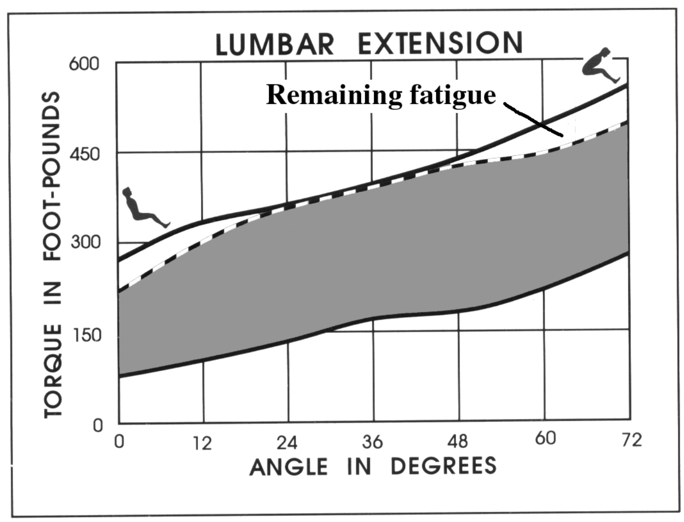
Lumbar Spine," we conducted several strength tests with a man named Gary Reinl, measuring the isolated strength of the muscles that extend the lumbar spine. While he is not a large man, Gary is unusually strong in most of his muscles as a result of many years of hard exercise; but our tests of his isolated lower-back muscles clearly established the fact that he is very weak in these muscles in spite of his years of hard exercise. His test results are clearly illustrated by the following charts.

fig. 2



The first chart shows the results produced by a three-part testing procedure called a "fatigue response test." The highest curve shown on this chart shows his level of strength throughout a full range of possible movement at the start of the testing procedures, his fresh, rested level of strength; this fresh strength curve is immediately above the red area shown on the chart.

fig. 3



Immediately after the test of his fresh level of strength was finished, he was exercised throughout a full range of possible movement, using a level of resistance that was only half of his fresh level of strength; but even with this relatively low level of resistance, he failed after only five repetitions of the exercise, then could not continue movement against that level of resistance.

Then, having exercised him to a point of momentary failure, we immediately measured his remaining level of strength. Test results that are shown by the lowest strength curve on the chart, the curve just below the shaded area on the chart. The shaded area indicates the degree of fatigue resulting from a very brief and relatively light exercise. A loss of fresh strength, fatigue, that was far in excess of what we expected; a clear indication that he had an unusually high percentage of so-called "fast twitch" fibers in his lumbar-extension muscles.

Secondly: both his strength tests showed an "abnormal" shape, indicating some sort of spinal injury. However, the abnormal shapes of the strength curves were not the same in both tests, which means that you cannot trust either one of them; one, or perhaps both, of the tests were invalid. Given valid and trustworthy test results, the shape of the strength curves should have been the same in both cases; while the level of tested strength might go up or down from one test to a second test, the shape of both resulting curves should be virtually identical.

The second chart shows the results produced by two valid tests of lower-back strength, tests conducted both just before and immediately after an exercise continued to the point of failure. The shaded area between the two strength curves represents fatigue resulting from the exercise; in this case a normal, or usual, degree of fatigue from such an exercise, which indicates that this subject had a usual mixture of muscular fiber types in his muscles.

But the most important factor, one that indicates that both tests were valid, is the fact that the shape of the curve did not change from one test to another test. The two strength curves shown here are almost identical insofar as shape is concerned.

Figure 3 shows the results of three tests of the same subject illustrated by figure 1; the third test shown on this chart was conducted four hours after the first two tests, for the purpose of determining just how fast he recovered from the fatigue resulting from the previous exercise. By that point he should have been fully recovered, but in fact showed a lot of remaining fatigue; indicating that this subject recovers very slowly from the effects of exercise, also indicating the fact that he almost certainly has a very low tolerance for exercise. Such subjects should not be exercised frequently or with high repetitions, cannot tolerate such exercise.

But the most important result shown by the third test was the fact that both the second and third tests produced the same shape in the strength curve; indicating that both the second and third tests were valid. It should also be noted that the shape of the curve was much the same in all three tests in the first half of a full-range movement, almost perfectly "flat." This subject produced invalid test results only in the second half of full-range movement during the first test. Why? We don't know why; perhaps he did not quite understand our instructions, or maybe he was afraid to exert a maximum level of effort during the second half of the first test.

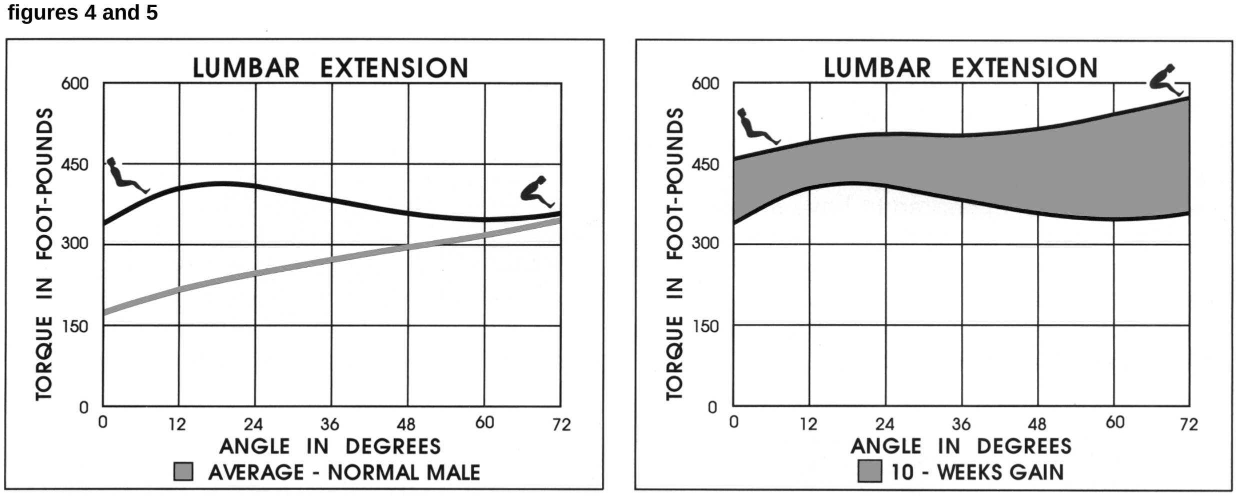
Nevertheless, even though part of the first test was invalid, we learned a lot from these tests: ONE, his level of lower-back strength was below average for a previously-untrained subject; TWO, he had a far higher than usual percentage of fast-twitch fibers in these muscles; THREE, he recovered very slowly from the fatigue resulting from an earlier exercise; FOUR, he had some sort of an abnormality, pathology, in his lower back.

Which tells us just what? It tells us that he should not perform such exercise more frequently than once a week, and he might do better if exercised only once every two weeks; and also tells us that he should never be exercised with high repetitions.

Even though this man had been suffering from lower-back pain for several years prior to these tests, nevertheless he was almost stunned by the test results, was very surprised to learn just how weak his lower-back muscles were. Having told me he intended to correct these problems very quickly, Gary returned to Philadelphia, where he was employed in a health club, and started training very hard on a Nautilus Lower-back machine. Four years later, having increased his strength on the Nautilus machine to a very high level during the period from 1987 until 1991, and then convinced that his lower-back strength was greatly improved, Gary visited us at the School of Medicine of the University of Florida, Gainesville. But then, when we tested the isolated strength of his lower-back muscles, we discovered that they were 22 percent weaker than they were when tested in New York four years earlier.

While steadily and greatly increasing the strength of his hip and thigh muscles as a result of training on the Nautilus machine, he was actually losing strength in his lower-back muscles. Two more years of regular training with similar machines, one year using a Cybex copy of the Nautilus machine and one year using a so-called Nautilus "Second Generation" machine produced very similar results: continued gains in strength in the hip and thigh muscles together

figures 4 and 5



with a loss in strength in his lower-back muscles. During that overall period of six years of steady training on those machines his lower-back muscles steadily lost strength from disuse atrophy.

Careful research performed over a long period of time with hundreds of subjects, research performed at the medical school in Gainesville as well as the medical school in San Diego, and in several other places, has clearly established the fact that almost all of the exercises now being performed for the purpose of increasing the strength of lower-back muscles are simply worthless for their intended purpose. So far, we have found only two exceptions to that general rule: ONE, so-called "hyper extension" movements performed on a simple bench called a "Roman chair," and, TWO, water-ski activities; but, in both cases, any resulting increases in lower-back strength are produced only near the fully extended position of the movement. That is, full-range improvement is not produced; a result that is clearly illustrated by the following charts.

The subject in figures 4 and 5 was a man named P. Q. Cotton, who was then a senior captain employed by Pan American Airlines, where he served as an instructor pilot in Boeing 747 "Jumbo jets." He was 51 years old, a bit over six feet tall, and weighed about 200 pounds; but the most important factor was the fact that he had been a professional water skier for a period of 36 years, an activity that had increased his lower-back strength to an enormous degree in some positions while doing literally nothing for it in other parts of a full-range movement.

This chart compares his fresh level of strength to the fresh level of an average, but previously untrained, man of his size. On the right side of this chart, which shows strength in the fully flexed position, which is usually by far the strongest position, his strength was only that of an average, previously untrained man; but in the fully extended position, shown on the left side of the chart, his strength was far above average, the high level of strength in that position being a result of his water ski activities.

Figure 5 shows the increases in strength that were produced by captain Cotton in his isolated lower-back muscles over a period of only ten weeks, as a result of only five exercises performed on a MedX Lumbar-extension machine; this subject was exercised on the MedX machine only once every two weeks, very brief and infrequent exercises that increased his full-range dynamic strength by 60 percent, while increasing his strength in the flexed position by 60 percent and in the extended position by 33 percent. In his initially strongest position, about 20 degrees forward from a fully-extended position, his strength was increased by 22 percent.

While 36 years of water ski activities did literally nothing for his lower-back strength in the flexed position, only ten weeks and five exercises on the MedX machine were required to increase his strength enormously in that position.

Dr. Michael Fulton, a board certified orthopaedic surgeon, a man who has been directly involved in our research for more than fifteen years, has served as team physician for several international water ski teams for nearly ten years, and this provided us the opportunity to test the lower-back strength of a large number of subjects, both men and women, who have been water skiers for long periods of time. Having tested them, we were not surprised to learn that their lower-back strength curves were very similar to the test results produced by captain Cotton; average, and sometimes below average, strength in the flexed position, but very strong near the fully-extended position.

Nor were we surprised to learn that a majority of these subjects had been suffering from lower-back pain for several years; pain that went away after their full-range lower-back strength was greatly increased by exercise on a MedX Lumbar-extension machine.

Exercises performed on a Roman chair produce similar results to those produced by water-ski activity, limited-range strength increases; and the degree of strength increases is nowhere near as great as those produced by MedX exercise.

No other muscles in the body that we are aware of have ever shown similar results in response to exercise, so it appears that the muscles of the lower back are unique in several important respects. Most people apparently go through life in a continuous state of lower-back weakness resulting from disuse atrophy, and thus have the potential for enormous increases in strength in these critical muscles when exposed to proper, full-range, isolated exercise. Proper exercise that can be provided only by MedX machines.

Before the development of the first, and still the only, testing machines that are capable of accurate and meaningful testing of strength, we did not anticipate the literally dramatic strength increases that would result from such proper exercise. Nor did we then expect that such results could be produced by very brief and infrequent exercise; now we never perform such exercise more than once a week, and perform only one exercise every two weeks with many subjects. More of such exercise will rarely, if ever, produce better results, and much more may produce losses in strength.

At least some people, if perhaps not most people, have been clearly aware, for a century or more, that we have three distinct levels of strength at any given moment; but, so far as I know, nobody was ever able to explain this fact until I came along, had failed to even notice something that I clearly understood as soon as I became aware of it. Some people notice things and some do not, will frequently attempt to deny things even after they have been clearly explained and demonstrated. This response, I believe, is usually a result of the so-called NIH factor, “not invented here.” Any idea that they have never previously been exposed to is immediately rejected as outright nonsense, and this usually occurs even when the facts are simply undeniable.

Having read everything I could lay my hands on that was related to the subject of exercise for about sixty years, I have found only two very brief mentions of friction; but even these two brief statements were made by people who obviously did not understand just how friction relates to muscular function. But, until and unless you understand the effects of friction in muscles, it is simply impossible to understand muscular function.

At first glance, the following statement may appear to be nonsense, but is, in fact, perfectly true . . . So long as the speed of movement remains constant, at any speed, then it takes exactly the same level of force to lift a weight, lower a weight, or hold a weight without movement. Lifting a weight involves “positive” work (or concentric work, as some scientists insist upon calling it), while lowering a weight involves “negative” work (or eccentric work, as some scientists insist upon calling it). Personally, I prefer the terms positive and negative, primarily because the terms concentric and eccentric are too similar, a similarity that frequently leads to confusion. But, as Shakespeare said . . . “A rose, by any name, would smell as sweet.” So it does not really matter what we call something, as long as we remain aware of just what we are talking about.

Think about it for a moment: how much force is required to lift 100 pounds of weight, at any constant speed of upwards movement? The answer? 100 pounds of force, no more and no less; because, if you exert more than 100 pounds of upwards force, then the speed of movement would not remain constant; instead, the speed of upwards movement would increase. So the fact that the upwards speed of movement remains constant is clear proof that the upwards force is exactly equal to the downwards force produced by gravity that is acting upon the weight.

And, of course, if the upwards force was less than 100 pounds, then the speed of upwards movement would be reduced; and, eventually, the weight would stop moving upwards, and then would start moving back down, steadily increasing the downwards speed of movement as it moved down.

And exactly the same situation exists during both negative work, lowering a weight at a constant speed, and while holding a weight with no movement either up or down. In all three cases, positive, negative, or static, it requires a force that is exactly equal to the weight being used.

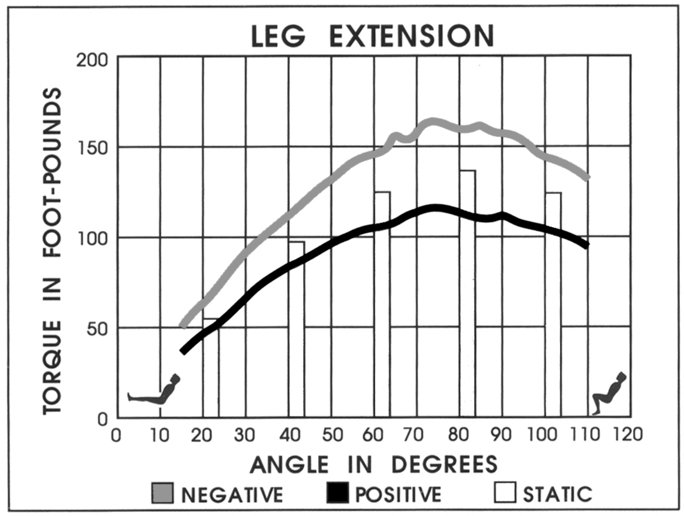
That being true, as it is, then why can you lower more weight than you can lift? Why is your negative strength greater than your positive strength?

Because of friction in the muscles, friction that reduces your positive strength but increases your negative strength. And just where did I read that? In an article entitled “Metabolic cost of negative work,” an article that I wrote in July, 1975, an article that was first published in the Athletic Journal in the issue dated January, 1976. An article that clearly spelled out the effects of friction in relation to muscular functions, but, unfortunately, an article that has been overlooked, or ignored, by almost everybody with an interest in exercise physiology.

Literally everything in the universe that has both mass and motion also has friction; and since muscles have mass, it follows that any muscular movement will produce friction.

About 75 percent of the energy that is produced by the engine of a car is wasted because of friction resulting from moving parts of the car. Which is not as bad as it might sound, because, without friction, your car would never start moving at all; instead, would remain in one spot while the wheels spun without producing movement of the car.

fig. 6



And, of course, without friction, it would be impossible to stop a car that was moving without running it into some object that was strong enough to withstand the resulting impact forces. And even if the object you ran into in order to stop the car was strong enough to withstand the impact forces, it does not follow that the car would not be damaged. Suddenly stopping a car at any speed above about 5 miles an hour will cause damage to the car.

When you are swimming, about 98 percent of the energy that your muscles are producing will be wasted by the friction of the water; which is why you cannot swim as fast as you can run.

Assuming that we are testing fresh muscles that are producing movement that is neither very fast or very slow, we will find, if our positive strength is 100, that our coexisting negative strength is about 140, about forty percent higher than our positive strength, while our static strength will be about 120, static strength being midway between the levels of positive and negative strength. A relationship that is clearly illustrated by the following chart.

Figure 6 shows the three distinct levels of strength that were recorded when a subject was tested in three ways, in order to determine the output of torque that was produced by maximum-possible efforts during positive work, negative work, and static work. Or, perhaps I should call it a static effort rather than static work, because without movement there is no work being performed. But regardless of what we call it, in all three cases we are measuring the output of torque produced by the force of muscular contraction.

If perhaps not quite impossible, it is certainly impractical to measure the level of force produced by muscular contraction; doing so would require you to sever the tendon that connects the muscle to the related bone, insert a strain gauge (a force measuring device) between the severed ends of the tendon, and then have the subject produce a maximum-possible level of static effort.

But doing so would be something less than desirable, to say the least, since we would have destroyed the muscular system that we were trying to test. So, instead, strength must be tested by measuring the levels of torque that are produced by the force of muscular contraction. But having done so, we still do not have an accurate measurement of strength; other factors must be considered. While torque is certainly produced by the force of muscular contraction, torque is also produced by gravity acting upon the mass of the involved body parts and by so-called “stored energy.” Two torque producing factors, gravity and stored energy, that have been ignored by everybody else who ever attempted strength tests.

By performing static tests, instead of dynamic tests, you can avoid the misleading effects of muscular friction, but you are still stuck with the effects of gravity and stored energy if you fail to deal with them properly. I will return to the subject of gravity and stored energy in a later chapter but will concern myself now only with the effects of muscular friction.

The three simultaneously coexisting levels of strength, the output of torque that were measured, are illustrated by the two strength curves and the bar graphs. The lowest level of strength was demonstrated during the test of positive strength, while the highest level was shown by the test of negative strength; but, in fact, both of those two test results were merely artifacts, did not show the true level of strength. Positive strength was reduced by muscular friction, while negative strength was increased by muscular friction, Only the static tests show the true level of strength.

If, for example, a muscle produces a level of force required to lift 100 pounds during a positive effort, the muscle is actually producing about 20 percent more force than is really required; because a meaningful part of the force of muscular contraction is wasted by muscular friction. Thus a positive test of strength will always produce test results that are too low, while a test of negative strength will produce test results that are too high. The only valid test of strength is a test of static strength; yet the self-appointed “experts” in this field generally show a decided bias in favor of dynamic tests, failing to understand that it is simply impossible to accurately measure strength while using a dynamic testing procedure.

My opinions? No, a simple statement of fact that could probably be clearly demonstrated to the total satisfaction of a cat; but can seldom be either explained or demonstrated to many, if any, of our current crop of scientists who are involved with, or interested in, exercise physiology. People who not only do not understand the basic laws of physics but generally are not even aware of them. So it appears that cats may be smarter than most scientists.