Three Apparent Levels of Strength

There are three apparent levels of strength . . . so-called positive strength, which is produced while a muscle is contracting . . . negative strength, which is produced when a muscle is lengthening under a load . . . and static strength, which is produced when a muscle is producing force without changing its length.

Positive strength is sometimes called concentric strength, negative strength is sometimes called eccentric strength, and static strength is usually called isometric strength; but I prefer the other terms, positive, negative and static.

It is generally assumed that your negative strength is greater than your positive strength . . . and there is certainly good reason for this assumption; except, as it happens, it simply isn't true.

It appears to be true only because of a failure to understand what is actually happening . . . and because of the fact that we can measure muscular strength only indirectly.

First, a very simple lesson in basic physics . . . a few points that may appear to defy common sense at first glance, but points that must be established before the rest of this chapter can be understood.

Question. How much force is required to *lift* 100 pounds at a steady rate of speed, any steady rate of speed?

Answer. Exactly 100 pounds of force, no more and no less.

How do we prove it?

By the use of pure logic . . . as follows. If the force was greater than 100 pounds, then the speed would not remain constant; instead, acceleration would be produced and the speed would increase. But since the speed is not increasing, then we know that the force is not more than 100 pounds.

If, on the other hand, the force was less than 100 pounds, then deceleration would result; the speed would be reduced, finally reduced to a point where motion was stopped entirely, and then motion in a downwards direction would be produced. But since such a loss of speed is not occurring, then it is obvious that the force is not less than 100 pounds.

And there is only one level of force that is neither more than 100 pounds nor less than 100 pounds . . . exactly 100 pounds.

Thus it should be clear that a lifting force is always exactly equal to the existing level of resistance . . . so long as the speed remains constant.

Question. Then how much force is required to *lower* 100 pounds at a constant speed?

Answer. 100 pounds of force . . . no more and no less.

If the force was less than 100 pounds then the weight would accelerate, the speed would increase . . . and if the force was more than 100 pounds, then the weight would slow down, would eventually stop, and would then move in an upwards direction at a constantly increasing speed.

But since the speed is remaining constant, we know that the force is exactly equal to the weight . . . and this is true whether you are lifting a weight, or lowering a weight, or simply supporting a weight with no movement upwards or downwards.

Thus it takes exactly the same amount of force to lower a weight, to lift a weight, or to support a weight. But if this is true, then why can you lower a far heavier weight than you can lift? Why is your negative strength greater than your positive strength?

It isn't, it only appears to be.

It is true that your functional ability is greater while working in a negative fashion . . . but your strength is the same whether you are lifting or lowering or holding a weight. Which, in all fairness, is a bit of a play on words, since I have not yet given my definition of strength. But if, by strength, we mean the strength of the muscle itself, the ability of the muscle to produce force, then it is the same in all three cases.

The output of force will not be the same, the functional strength will not be the same, but the production of force will be the same . . . the difference in output being a result of friction within the muscle itself.

Nor is it a mere coincidence that the level of static output of force is always midway between the level of positive output and the level of negative output . . . because, in a static mode, there is no friction, and thus the output is equal to the input.

In very simple terms . . . a static measurement of strength is the only meaningful measurement of strength, the only accurate measurement of strength. Dynamic tests conducted in a positive fashion produce strength measurements that are too low, and dynamic tests conducted in a negative fashion produce strength measurements that are too high.

When the functional strength produced by a fresh muscle is measured in a positive fashion, with a resulting strength level of 100 (100% of some number), if the same muscle is then tested in a negative fashion then the level of functional strength will be approximately 140; thus your functional negative strength is about forty percent higher than your functional positive strength.

But if you then test the same muscle in a static fashion, your strength will be 120 . . . midway between your positive level and your negative level.

In fact, the real strength of your muscle was the same in all three cases . . . that is, your muscle was producing the same amount of force in all three cases, exactly the same. Muscular friction was responsible for the differences in output.

Thus a test of positive strength will always produce a test of static strength minus friction, and a test of negative strength will produce a test of static strength plus friction. Friction hurts you during positive work and helps you during negative work . . . but neither helps you nor hurts you during static efforts.

Opinion? No, a simple fact; but a fact that most people in this field remain completely unaware of. In the last part of this book I have republished a few of my older articles, and I now wish to call your attention to the article "The Metabolic Cost Of Negative Work."

That article was written in 1975, over twelve years ago, was submitted to The Athletic Journal and was first published in the issue dated January of 1976. In that article I clearly stated that the apparent differences in negative and positive strength levels were a result of internal friction.

The subject of measuring strength will remain confused until this relationship of positive to negative to static levels of strength is clearly understood by everybody in this field. Confusion resulting from a failure to understand this relationship has produced a rather widespread bias in favor of dynamic tests, and a bias against static tests.

It is generally assumed that your negative strength is greater than your positive strength.

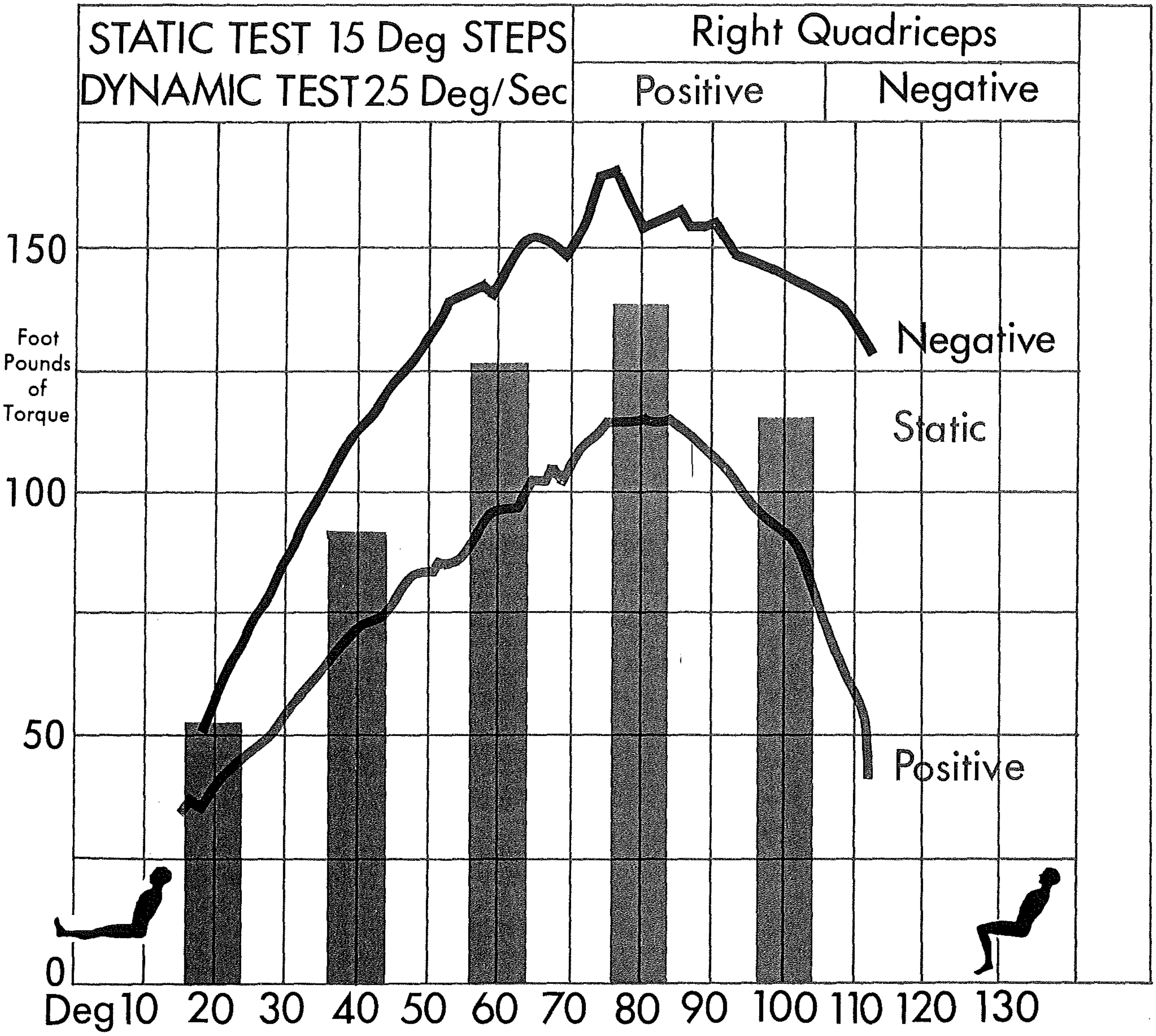

CHART 1

FIGURE 8. **This chart displays the test results of all three levels of functional strength . . . positive, static and negative. Maximum strength test results of fresh muscles, the quadriceps of the thighs.**

The bar graphs represent the fresh level of static strength in various positions through a full range of possible movement.

The blue curve displays the fresh level of positive strength throughout a full range of movement.

The red curve shows the fresh level of negative strength throughout a full range of movement.

The positive strength is the lowest, the negative strength is the highest, and the static strength is midway between.

But in fact, the force produced by the muscle was the same in all three cases; your real level of strength is the static level . . . positive strength is reduced by the friction within the muscle itself, while negative strength is increased by the internal muscular friction.

With a fresh muscle, contracting at a slow speed, approximately 17 percent of the force being produced by the muscle will be wasted by friction during a positive movement while a fresh muscle that is lengthening under a load, during a negative movement, will be far stronger as a result of friction.

But there is no friction during a static contraction, so the output of the force will be exactly equal to the force actually being produced by the muscle.

Internal muscular friction hurts you during positive work, helps you during negative work, and has no effect during a static contraction.

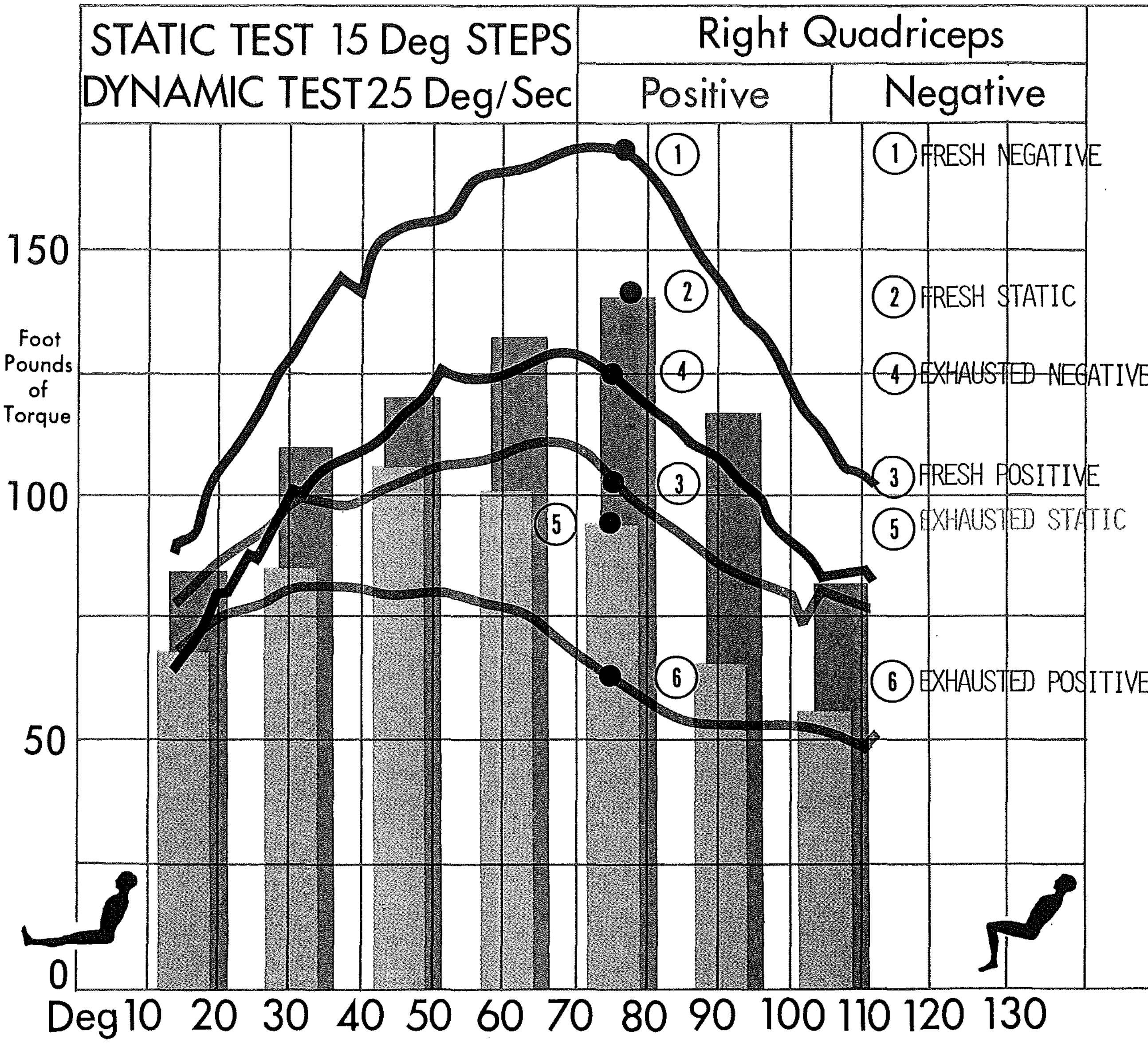

CHART 7

FIGURE 9. **With a fresh muscle, if your positive strength is 100 then your static strength will be 120 and your negative strength will be 140. In all three cases the muscle is producing a force of 120 . . . but the output will be 120 only during a static contraction. During positive work 20 will be wasted by friction and the output will be only 100. During negative work the friction of 20 will be added to the muscular input of 120 and the resulting output will be 140.**

But that ratio applies only to a fresh muscle that is contracting or lengthening at a fairly slow speed. An increase in the speed of movement will increase the level of friction . . . and fatigue will increase the level of friction.

Worked to a point where the positive level of remaining strength is zero, the static strength will still be 60, while the negative strength will be 120.

60 pounds of force from the muscle minus 60 pounds of friction equals zero, your positive strength at that point. 60 pounds of force from the muscle plus 60 pounds of friction equals 120, your negative strength at that point. But your real strength is 60.

We have conducted thousands of such tests, and the results are always the same; the static level of strength is always midway between the positive and negative levels, at any speed of movement and at any level of fatigue.

This chart shows the results of six different tests; two tests of static strength, two tests of positive strength and two tests of negative strength. All three lev-

The faster the speed of contraction, the higher the level of internal muscular friction.

els of strength were tested with fresh muscles, and then the subject was exercised with both positive and negative resistance until a marked degree of fatigue was obvious.

Then the fatigued levels of strength were tested, positive, static and negative. Look at the areas on the chart marked by numbers within small circles; numbers 1, 2 and 3 represent the fresh levels of negative, static and positive strength, in that order. . . while numbers 4, 5 and 6 represent the levels of fatigued strength, in the same order.

Note that the static level is always between the other two levels, at any level of fatigue.

The relationship between these three levels of functional strength is not so clear on either end of a full range test, because of unavoidable problems associated with any sort of dynamic test; at the start of a dynamic test the movement occurs instantly but you cannot recruit all of the available muscle fibers instantly, so your measured output of dynamic strength will usually be too low during the first part of the movement.

Then, because of the continuous nature of the contraction, four seconds in this case, some subjects will start to lose strength from fatigue during the last part of a dynamic test; again producing measured results that are too low.

But in the mid-range of possible movement, if the subject is trying in all three tests, then the results will always be the same.

The muscle is producing exactly the same level of force in all three cases, but the measured output of functional strength will not be the same, because of friction; thus your real level of strength is your static level, while both positive and negative levels of strength are artifacts that have been biased by friction . . . actually tell you nothing about what the muscle is doing.

I published this information in very simple terms twelve years ago, yet most people still remain unaware of this relationship and will continue to be confused and frustrated in their attempts to measure strength until they do understand this situation.

Additional confusion has resulted from the fact that muscular strength cannot be measured directly; we cannot insert a strain gauge between the end of a muscle and its related tendon in order to get a direct reading of the actual level of force being produced by the muscle.

Instead, we must be content with measuring strength indirectly; by testing the functional output of force produced by a body part being moved by muscular force. Which unavoidably involves another factor of enormous consequence, the joint system of the body; the result being that a functional output of force is meaningless for the purpose of testing the actual strength of the muscles themselves if this factor is ignored.

Less than eight percent of the actual level of force produced by the quadriceps muscles is used for moving the lower legs in the direction of extension . . . meaning that more than ninety-two percent of the muscular force is wasted due to a grossly inefficient joint, the knee.

In contrast, the muscles of the lumbar are connected to a very efficient joint system that provides these muscles with a mechanical advantage. . . an advantage of leverage so great that the muscular force is increased by at least a factor of two and perhaps by a factor of four. Meaning that a muscular force in the lumbar extension muscles of only 100 pounds will produce a measurable output of at least 200 pounds, and perhaps as much as 400 pounds.

But in either case we are testing functional strength, not muscular strength . . . and the fact that functional strength is in some proportion to muscular strength is meaningless, even if the proportionate relationship is known, which it seldom is. Is meaningless primarily because the relationship changes with movement, may change as much as 1,000 percent from one end of a movement to the other end.

If the production of muscular force remained constant throughout a full range of movement, which it does not . . . but if it did, then the output of measured functional force would vary by as much as 1,000 percent. Meaning that you would be ten times as strong in some positions as you were in other positions.

Then, if movement is involved, as it is in any sort of dynamic test, other factors contribute even more confusion.

Friction . . . the friction within the muscle itself; internal muscular friction will waste at least sixteen percent of the muscular force in any positive test. But we cannot compensate for this by adding a certain percent to our tested level of dynamic strength because friction within the muscle varies as a consequence of at least two factors, speed of muscular contraction and the existing level of fatigue . . . neither of which factors can ever be known with any meaningful degree of accuracy.

The faster the speed of contraction, the higher the level of internal muscular friction. . . and the friction also increases from fatigue; a fatigued muscle may have three times as much friction as a fresh muscle, or more.

But in a dynamic test of negative strength we have an opposite situation; rather than reducing our functional strength the friction actually increases it.

Again, this situation produces changes in measured levels of negative functional strength that vary greatly depending both upon the speed of movement and the level of fatigue. So we cannot compensate by subtracting any given percentage from the measured levels of functional force produced by a dynamic negative test.

Nor is that all there is to it, even more factors are involved, all of which produce more confusion; the ability to recruit and involve all of the available muscle fibers varies from one individual to another, and varies from one muscle to another muscle in the same individual. Which means that the speed of movement will change the tested output of functional force by as much as several hundred percent. In fact, when the involved body part is moving as fast as possible then the output of tested functional force will be zero . . . regardless of the strength of the muscles producing the movement.

Which might lead you to believe that it is impossible to measure muscular strength in any meaningful way . . . and it is impossible in most of the ways that are being attempted at the moment.

But you can measure functional strength very accurately, if you go about it properly . . . and having done so, then you have a basis for comparing changes in muscular strength. While you will never know the actual level of force being produced by the muscle, you will know the direction and magnitude of change. Which is all you need to know.

Meaningful testing of functional strength can be done only under certain circumstances . . . a general failure to understand the requirements for such testing has added to the present confusion on this subject; leading to the proliferation of a wide variety of conflicting theories, many of which are simply ridiculous. . . some of which are dangerous.

Dangerous because they involve testing procedures that produce very high levels of force . . . while providing tests results that are utterly meaningless.

If you believe that there is no relationship between static strength and dynamic strength, then you may have a bias in favor of dynamic testing procedures; but the fact of the matter is that your muscles have only one level of strength, can produce a given level of force under any circumstances provided only that enough time is available for the muscle to recruit all of its available fibers.

Meaning . . . the muscle can and will produce exactly the same level of force, regardless of the direction of movement or the speed of movement; exactly the same level of force positive, negative or static, moving or not moving, lengthening or contracting, moving very slowly or moving as fast as possible. The muscular force will be the same in all cases; but the output of measurable force will certainly not be the same, will vary from zero to a very high level.

Your muscular strength will thus be constant, while your functional strength will vary enormously; but since you are able to measure only the functional strength then the test results will unavoidably be very confusing.

Which is certainly not meant to imply that your muscular strength remains constant in every position . . . it does not; instead, your muscular production of force varies as you move from one position to another . . . but most of the variation that occurs in functional strength as a result of changing positions is a result of other factors. Factors mentioned earlier in this chapter, factors to be covered in great detail in later chapters.

If dynamic tests could be conducted with perfect accuracy, and if they were conducted at exactly the same speed, and if they were conducted exactly the same way each time, and if more than a dozen other requirements were provided . . . then, if you know just how much to add to a positive test or subtract from a negative test to compensate for muscular friction, you would have a meaningful test of strength.

Isokinetic tests of dynamic strength provide a constant speed of movement . . . which, ironically, hurts such tests rather than helping them.

If you did provide all of the requirements, and if you did know how much to add or subtract in order to compensate for muscular friction, you would still produce meaningless test results if you used an isokinetic source of resistance . . . because isokinetic resistance produces impact forces that magnify the levels of force actually being produced by the muscles. The measured forces will vary by as much as several hundred percent from the true level of force produced by the muscles and measured as an output of functional strength.

Meaning that a muscle may produce 500 pounds of force, while the related body part may move with a measurable output of functional force of only 200 pounds, yet the isokinetic resistance might magnify this level of force to as much as 1,000 pounds or more as a con-

The speed of movement will change the tested output of functional force by several hundred percent.

It is possible to produce meaningful and accurate test results even in a dynamic fashion.

sequence of impact forces.

Enormous amounts of rather widely believed propaganda to the contrary, isokinetic testing is literally worse than worthless; worse because it is misleading, and worse because it is dangerous.

Which is why, after nearly twenty years of such tests, after hundreds of research programs using isokinetic devices in an attempt to measure the output of muscular function . . . nothing of any slightest value has been learned. Quite the contrary, instead of providing knowledge such tests have merely added to an already high level of confusion.

In a recent issue of Spine magazine, the reported results of isokinetic tests of trunk-flexion indicated far higher levels of strength during dynamic positive tests than the levels measured in a static fashion; which is utterly ridiculous, simply impossible.

Yet such results get published in medical journals and are then accepted by some people simply because of the source.

In most of these reported tests they produced higher levels of force at a relatively fast speed of movement than they did at a slower speed; which is ridiculous, as the following example should clearly establish.

Take a barbell weighing 50 pounds, stretch out on your back on a bench and then perform a bench-press . . . moving as fast as possible, literally slamming the barbell up as quickly as you can.

Film the movement, and then time the movement by counting the number of frames required to lift the barbell from your chest to a position at arms length above your chest.

Then repeat the test with a barbell weighing 100 pounds . . . then with 150 pounds . . . then 200 pounds, and so on. You will find that the speed of movement will decline in inverse ratio to the increase in resistance. The higher the resistance, the slower the speed. Nothing else is even possible; the involved physical law should be obvious to anybody simply from everyday experience.

Then how do they manage to produce higher levels of force at faster speeds of movement?

They don't, they can't, since doing so is impossible; what they can do, and what they are doing, is recording impact forces and attributing these forces to the muscles.

One more example. Push your fist against a brick wall as hard as possible; doing so will produce the highest level of force that you are capable of producing with the involved muscles, but it will not be painful because you will be exposed to exactly the same level of force that you are producing, not enough to hurt.

Then slam your fist against the brick wall as fast as possible. Do you really believe the result will be equally comfortable?

In this case you will break your hand, perhaps your wrist as well . . . because you will be exposed to a far higher level of force, a dangerous level of force. Even though the force produced by your muscles was actually lower than it was when you pushed your fist against the wall. Lower because the fast speed will not afford you the time required to recruit all of the available muscle fibers.

Your hand and wrist will be destroyed by impact forces resulting from the fast speed of movement and the sudden stop; an actually low and safe level of force will be magnified into a resulting level of impact force that will hurt you badly.

Which is exactly what happens during attempts to test strength in any sort of isokinetic machine. Which is why they produce test results that are utterly ridiculous, simply impossible.

One final example. Stand quietly on a scale and observe the figure indicating your weight. If the scale is accurate then the weight will be accurate . . . but only when you are standing perfectly still.

Then observe what happens to the recorded forces when you jog in place on the scale. If you weigh 200 pounds then the recorded forces will vary from zero to as much as 800 pounds or more. Which result will tell you nothing of value about your weight.

All of which should be obvious to anybody, but certainly is not obvious to some people; the problem being that a lot of other people are encouraged to perform meaningless tests in a dangerous fashion by reading published statements that are simply ridiculous.

Ridiculous and dangerous. Danger to no purpose.

Yet it is possible to produce meaningful and accurate test results even in a dynamic fashion . . . and in a safe manner; but only when all of the requirements are clearly understood and provided, and this cannot be done while using any sort of isokinetic resistance.

Requirements that are clearly spelled out in following chapters.

I will return to the subject of the three apparent levels of strength, and to the subject of internal muscular friction, in later chapters; because a clear understanding of these factors is essential for an understanding of much that follows. But all you need to remember at the moment is that your muscles really have only one level of strength. Despite appearances to the contrary.

Present and Future Products

We are now accepting orders for reasonably early delivery of a wide range of machines designed for both functional testing and proper rehabilitative exercise . . . some of which equipment is now available for almost immediate delivery.

Our current line of equipment consists of two versions of each of seven different machines:

1. **Lumbar-Extension Machine**
2. **Rotary-Torso Machines**
3. **Abdominal Machines**
4. **Leg-Extension (Quadriceps) Machines**
5. **Leg-Curl (Thigh-Biceps) Machines**
6. **Neck-Extension Machines**
7. **Rotary-Neck Machines**

The most sophisticated versions of these machines combine all of the required features for accurate, meaningful, isolated and safe testing of muscular function, together with proper rehabilitative exercise for the same muscles.

Less expensive versions of the same seven machines are available for the single purpose of providing proper rehabilitative exercise.

The individual requirements for a particular type of testing machine vary somewhat, depending upon the muscles being tested and the nature of the movement involved; for example, a lumbar-extension machine requires features which permit compensation for both torso-mass centerline variations and magnitude of torso-mass variations . . . whereas, a rotary-torso machine does not require these features, because the movement is a lateral movement and random torque resulting from the torso-mass of the subject is not involved.

In general, all of our equipment includes the following list of functions and features; all of which are absolute requirements for safe, accurate testing procedures and for proper rehabilitative exercise. As mentioned above in the example related to the torso-rotation machine, a few of the machines do not require all of these features; but where they are required, they are provided.

FUNCTIONS:

1. TOTALLY-SPECIFIC TESTING
2. TOTALLY-SPECIFIC EXERCISE, POSITIVE & NEGATIVE
3. STRENGTH TESTING
4. ENDURANCE TESTING
5. WORK-CAPACITY TESTING
6. FIBER-TYPE TESTING
7. RANGE-OF-MOTION TESTING
8. MUSCULAR-FRICTION TESTING
9. MUSCLE-FIBER RECRUITMENT TESTING
10. NEGATIVE-ONLY TESTING
11. NEGATIVE-ONLY EXERCISE
12. TRUE-DYNAMIC TESTING
13. TRUE-DYNAMIC EXERCISE
14. WORK MEASUREMENTS
15. POWER MEASUREMENTS
16. MEASUREMENTS OF METABOLIC WORK
17. RECOVERY TESTING
18. FATIGUE TESTING

19. STRENGTH-POTENTIAL TESTING
20. PRE-EMPLOYMENT SCREENING
21. STRETCHING
22. PRE-STRETCHING
23. REFUTATION OF FALSE CLAIMS
24. DETECTION OF UNSUSPECTED OR DENIED INJURY
25. TYPE S AND TYPE G TESTING
26. EFFECTS TESTING
27. RESULTS TESTING
28. APPARENT-PARALYSIS TESTING

FEATURES:

1. AUTOMATICALLY VARIABLE RESISTANCE
2. DIRECT RESISTANCE
3. BALANCED RESISTANCE
4. FULL-RANGE RESISTANCE
5. MINIMUM AVAILABLE RESISTANCE 2 & ½ FOOT-POUNDS
6. INCREMENTAL INCREASES IN RESISTANCE OF 2 OUNCES
7. LOW-VELOCITY RESISTANCE
8. RESISTANCE DISCONNECT
9. ZERO FRICTION RESISTANCE
10. COMPUTER CONTROL
11. VISUAL FEEDBACK ON COMPUTER SCREEN
12. TESTING-ACCURACY ABOVE 99 PERCENT
13. REPEATABILITY ABOVE 99 PERCENT
14. EFFICIENCY ABOVE 99 PERCENT
15. KINETIC ENERGY BELOW 13 PERCENT
16. AXIS OF ROTATION ALIGNMENT 100 PERCENT
17. TORSO-MASS COMPENSATION 100 PERCENT
18. TORSO-MASS CENTERLINE COMPENSATION 100 PERCENT
19. MACHINE-COMPONENT COUNTERBALANCING 100 PERCENT
20. TESTING POSITIONS WITHIN 1 & ½ DEGREES
21. RANGE OF MOTION LIMITING, INFINITE THROUGHOUT FULL RANGE
22. LOWEST LEVELS OF TESTING AND EXERCISE FORCE
23. GRADUAL FORCE-APPLICATION
24. BODY-PART RESTRAINT
25. DIGITAL READOUT OF POSITIONS
26. TOTAL PELVIC RESTRAINT
27. PELVIC-MOVEMENT INDICATOR
28. ACCELERATION
29. MACHINE FRICTION BELOW 1 PERCENT
30. ZERO FORCE, ENTRY AND EXIT
31. BODY-SIZE VARIATIONS, (FROM LESS THAN 5 FT TO ABOVE 7 FT)
32. UNRELATED-MUSCLE FORCE REMOVAL
33. UNDAMPED TEST RESULTS
34. MEANINGFUL TEST RESULTS
35. ACCURATE TEST RESULTS
36. SAFETY . . . Without safety, nothing else matters; our primary concern has been and will be safety. While any form of testing or exercise involves imposing some level of force on the subjects, from as little as two ounces in some of our machines to as much as is desired or required, the highest level of safety can be, and should be, provided; which involves many factors, but primarily means keeping the levels of force as low as possible and under total control.

Every possible safety feature that can be provided in any sort of exercise or testing machine has been incorporated into our machines; they are, quite literally, the safest machines for their intended purposes that can be designed or built.

In the highly unlikely event that we are ever able to improve the safety of our machines as a result of our continuing research, then we will retrofit any and all such features into all of our equipment in service . . . at our expense.

None of the above listed functions or features of our equipment are provided in either a safe or meaningful manner by any other type of equipment in the world . . . nor can they be in the next seventeen years, because they are all covered by our patents pending.

None of our present line of products were offered for sale until we were totally satisfied with them, and we are hard to please; not offered for sale until I was personally convinced that they were far past any chance of functional improvement . . . accurate, meaningful, and safe beyond any slightest chance of improvement. And they are.

Nothing less is acceptable . . . nothing more is even possible.

Any future additions to our present line of equipment will have to meet the same high standards of excellence. No compromise; the field of muscular testing and rehabilitative exercise is far too imporant to permit even the slightest degree of compromise.