Nautilus
&
Athletic Journal
Articles

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From Here to Infinity... or very close

Featuring the Duo Squat Machine

Starting in 1968, I published a rather large number of articles and books for a period of about seven years, carefully spelling out a few points that I considered to be of great importance in the field of exercise. But I have published almost nothing during the last seven years, for several reasons. Primarily because I really did not feel that I had anything new to add.

Now I do.

The first practical application of this new breakthrough is already on the market, the Nautilus Duo Squat Machine. The first piece of equipment of any kind that properly varies the resistance during a compound exercise.

Everything being equal, a compound exercise is always a much more productive exercise than a single-axis exercise, for the simple reason that it involves a far greater mass of muscle. Thus the barbell squat is a more productive exercise than a barbell curl.

But carefully note the qualification… everything being equal. The problem is, everything isn't equal.

With the use of a cam, a positive cam, the first Nautilus curling machine produced a literally enormous increase in the productivity of the curl as an exercise. In comparison to a curl performed with a barbell.

Why? And how?

Because, by providing a source of resistance throughout the entire range of possible movement, the Nautilus curling machine produced resistance for the total length of the muscles involved in bending your arms.

And, secondly, because the cam varied the resistance properly throughout the entire range of possible movement.

The result being that you were working the muscles properly, providing overload throughout a full range of possible movement. Full range, proper exercise.

In contrast, a barbell curl does not provide resistance throughout the entire movement… and, secondly, the resistance that is provided in a barbell curl does not vary properly, does not vary in proportion to the actual need for variable resistance.

The result being that a barbell curl works the bending muscles of your arms only in the mid-range of possible movement, thereby producing a distinctly peaked strength curve… strong in the middle, but weak on both ends.

Did I say that a barbell provides variable resistance? Yes, I did… and it does.

But the variation in resistance that is provided by the barbell has absolutely nothing to do with the variation in resistance that is actually required for the proper development of your muscles.

The variation in resistance that is provided by a barbell is utterly random in nature… while the variation in resistance that is required for the proper development of your muscles is very specific.

In one or two relatively unimportant exercises, the random variation in resistance that is provided by a barbell is so close to being right for a particular movement that it would be very difficult to improve the exercise to any significant degree; the best example of this being the wrist curl performed with a barbell… performed properly, as it seldom is.

But that is an exception… not the rule.

The Arthur Jones Collection

I can think of no single example of an important exercise where the random variation of resistance provided by a barbell is an advantage, but many examples to prove that it affords a problem.

More than nine years ago, in 1973, we built a squat machine for our use during an experiment we conducted in Colorado… then, a few months later, we built a second version of this machine. The second machine was used, in 1975, during an experiment at the Military Academy in West Point.

But neither of these machines was ever manufactured for sale to the general public… because both versions still left a great deal to be desired; because, at the time we built those machines, we simply did not know how to vary the resistance properly in an exercise such as the squat.

More than that… because, at that time, we still believed that it was utterly impossible to vary the resistance during an exercise such as the squat.

Eight months ago, we still believed it was impossible, but now we are doing it, thanks to the negative cam.

Improving an exercise such as the curl is one thing… but producing an equal degree of improvement in an exercise such as the squat is an entirely different matter, for a number of reasons.

In a curl, or in any single-axis exercise, you are dealing with degrees of rotation. Rotational movement around one axis of the body.

In a squat, or in any compound exercise, you are dealing with a relatively straight line of movement. A resultant of the rotational movements around two or more points.

In a curl, movement is limited to rotation around the axis of the elbows. Or should be, and is if a curl is performed properly.

But in a squat we have a far more complex situation… rotational movement occurs around the axis of the hips, around the axis of the knees, and around the axis of the ankles. Thus a squat is properly called a compound movement… meaning that rotation occurs around two or more axis points. And, of course, a curl is properly called a single-joint movement.

Your strength varies during both types of movement, so variation in the resistance is required during both compound exercises and single-axis exercises… but here the similarities ceases, and the problems start.

Because, to start with, your strength varies much more in a compound movement than it does in a single-axis movement. And, secondly, because the pattern of variation is much different.

In a curl, for example, the required resistance increases during the first part of the movement and then decreases during the last part of the movement… goes up, reaches a peak, and then goes back down.

But in a squat, the proper resistance must start fairly high, go down as you approach the so-called sticking point, and then increases rapidly when the sticking point is passed.

Thirdly… during a properly performed curl, the muscles remain under load throughout the movement. The resistance is not removed from the muscles at the top of the movement. Whereas, in the squat, the resistance is removed from the muscles in the top position. A point of so-called lock-out is reached where the load is supported entirely by your bones.

A careful examination of illustration number one will make several of these differences obvious. The dotted line represents your strength curve during a curl… while the heavy, solid line represents your strength curve during a squat.

A normal cam, a positive cam, can easily provide the variation in resistance that is required in a curl… but a positive cam cannot even begin to properly provide the variation in resistance that is required in the squat. But a negative cam can.

The resistance varies less than fifty percent in a properly designed curling machine, and a positive cam is easily capable of providing that degree of variation. But your strength varies by several hundred percent during a squat, and a positive cam simply cannot meet the requirements.

While it is certainly true that a cam is the only practical way to properly provide the variation in resistance that is required in exercise… it does not follow that the addition of a cam will automatically improve an exercise machine.

The cam must be right… must provide the proper variation in resistance required by a particular movement. The variation in resistance that is right in one movement is utterly wrong in any other movement… because each movement has a very distinct strength curve.

So each movement requires a different cam. But a cam can be different while still being wrong. And how do you know that a cam is right? By the results.

During the performance of almost all barbell exercises, you will encounter a point in the movement where the resistance feels very heavy… a so-called sticking point.

You will also encounter one or more positions during the movement where the resistance feels very light… or where the resistance falls off literally to nothing.

And it does not matter how long you train with a barbell, you will always encounter the same sticking-points, and the same points of little or no resistance.

So it is thus obvious that the random variation in resistance that is provided by a barbell does not match the need for variation that is actually required.

Well, you might say, then all you need to do is to test the actual strength curves of one or more people and then build a machine that provides the same variation in resistance.

But that won't work either… because the actual strength curve has little to do with the potential strength curve. What it is does not indicate what it can be, or should be.

Giving a reading test to an utterly unschooled subject might tell you what his reading ability was at the moment… but it would tell you absolutely nothing about his potential.

Or… giving the same test to a subject that had been taught improperly might give you even worse results.

And the same analogy is applicable when it comes to strength tests; any sort of test you can think of is utterly worthless for the purpose of determining what the strength curve of a person can be, and should be.

In any case… apart from highly sophisticated, one-of-a-kind equipment that was developed by Nautilus, nobody else in the world has the ability to accurately measure strength curves. One such tool that has been on the market for several years was recently shown to be in error by as much as five-hundred and twenty percent.

I first became aware of the need for variation in the resistance in exercise in 1939… but it then took me thirty years to figure out what the actual variation in resistance should be. In the end, the solution was so simple that it should have been obvious to me from the start… one of those "why didn't I think of that sooner" type of things.

But how can I be so sure that the variation in resistance provided by Nautilus machines is proper? And, of perhaps greater importance… how can you be sure that it is proper? As I said earlier… by the results.

Your strength will never accommodate itself to the improper variation in resistance that is provided by a barbell… and the same thing is true in regards to an exercise machine that provides the wrong variation in resistance.

But your strength will accommodate itself to the variation in resistance that is provided by an exercise machine that provides the proper variation in resistance.

When you first use a Nautilus machine, it is almost certain that you will encounter a so-called sticking-point in the movement… an area in the movement where the resistance will feel too heavy. And it is also almost certain that you will encounter one or more positions where the resistance will feel too light. But that situation will change… and very quickly. Whereas, with a barbell, or with another type of exercise machine… that situation will never change.

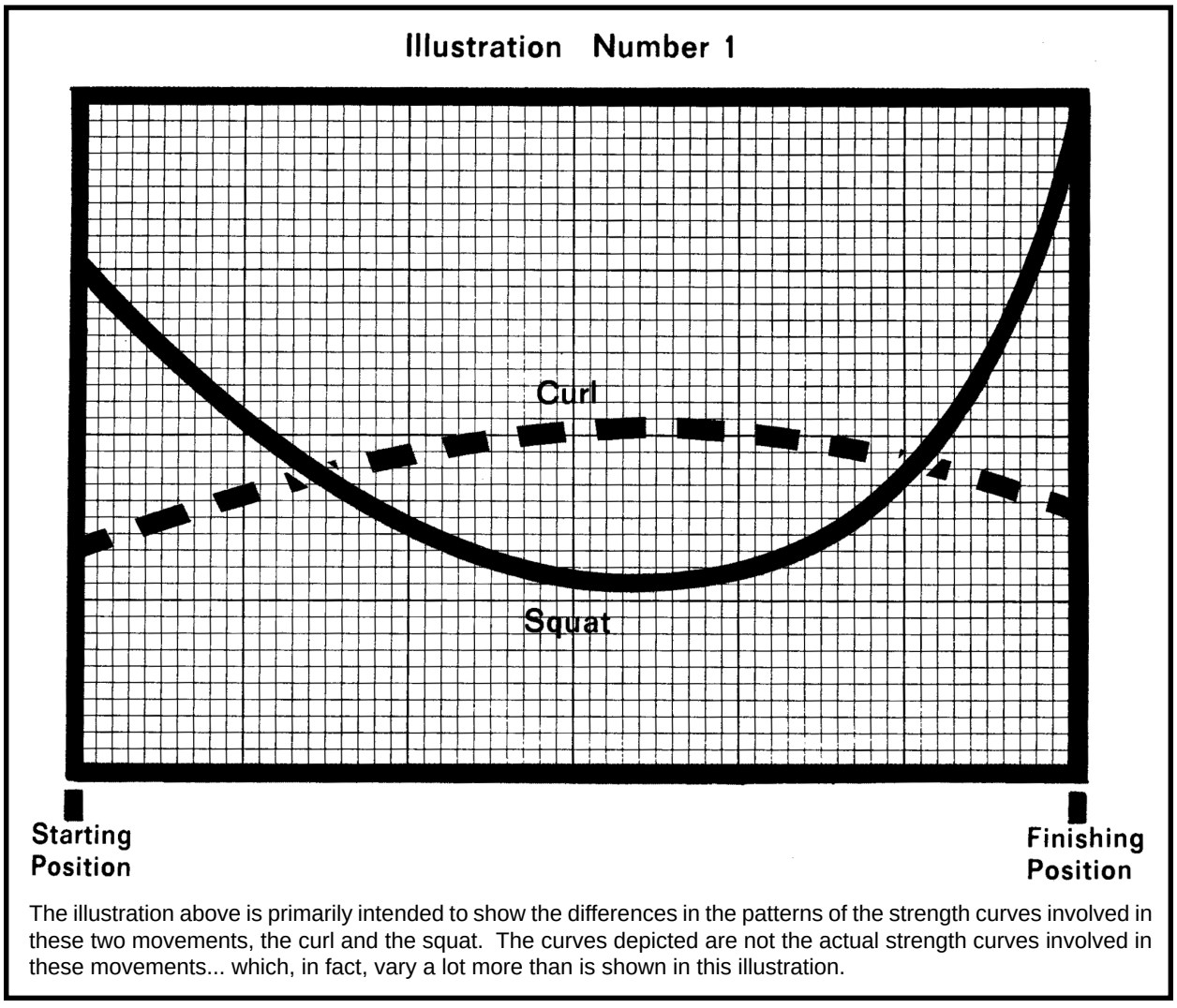
Within a very short space of time, the resistance provided by a Nautilus machine will feel perfectly smooth… that is, it will feel the same in every position throughout a full range of possible movement. It will feel the same in every position in spite of the fact that the resistance is constantly changing… because the changes in resistance will be in exact proportion to your changes in strength. If the variation in resistance was wrong, then it would never feel smooth… but if it is right, then it will feel smooth.

During an experiment at the United States Military Academy in 1975, we found that the dynamic strength of a group of cadets increased by sixty percent in one movement within a period of less than six weeks. That is to say that they could perform a full-range movement with sixty percent more weight. However… their static strength increased only six percent at their strongest point in the movement. Which might lead some people to believe that there is no relationship between dynamic strength and static strength… but if so, then they are utterly wrong. Because… we also found that the same subjects increased their static strength in the starting position of the movement by exactly one-hundred percent, and their static strength in the finishing position of the movement by one-hundred and forty percent.

Illustration number two will make these points clear… the dotted line represents the starting strength curve, and the heavy, solid line represents the finishing strength curve. You will also notice that the final strength curve was much flatter than the starting strength curve.

And, while it is true that a perfect strength curve in this movement will never be totally flat, it is also true that the starting strength curve of these cadets was peaked much too high in the mid-range of possible movement. Too high in proportion to their strength in the starting position, or in the finishing position. This being the unavoidable result of training with exercises that provided little or nothing in the way of meaningful resistance at either the start or the finish of the movement.

So six weeks of proper training increased their strength in their strongest position by only six percent, an average of approximately one percent per week… while increasing their strength by one-hundred and forty percent in their weakest position, an average of approximately twenty-three percent per week.



The illustration above is primarily intended to show the differences in the patterns of the strength curves involved in these two movements, the curl and the squat. The curves depicted are not the actual strength curves involved in these movements... which, in fact, vary a lot more than is shown in this illustration.

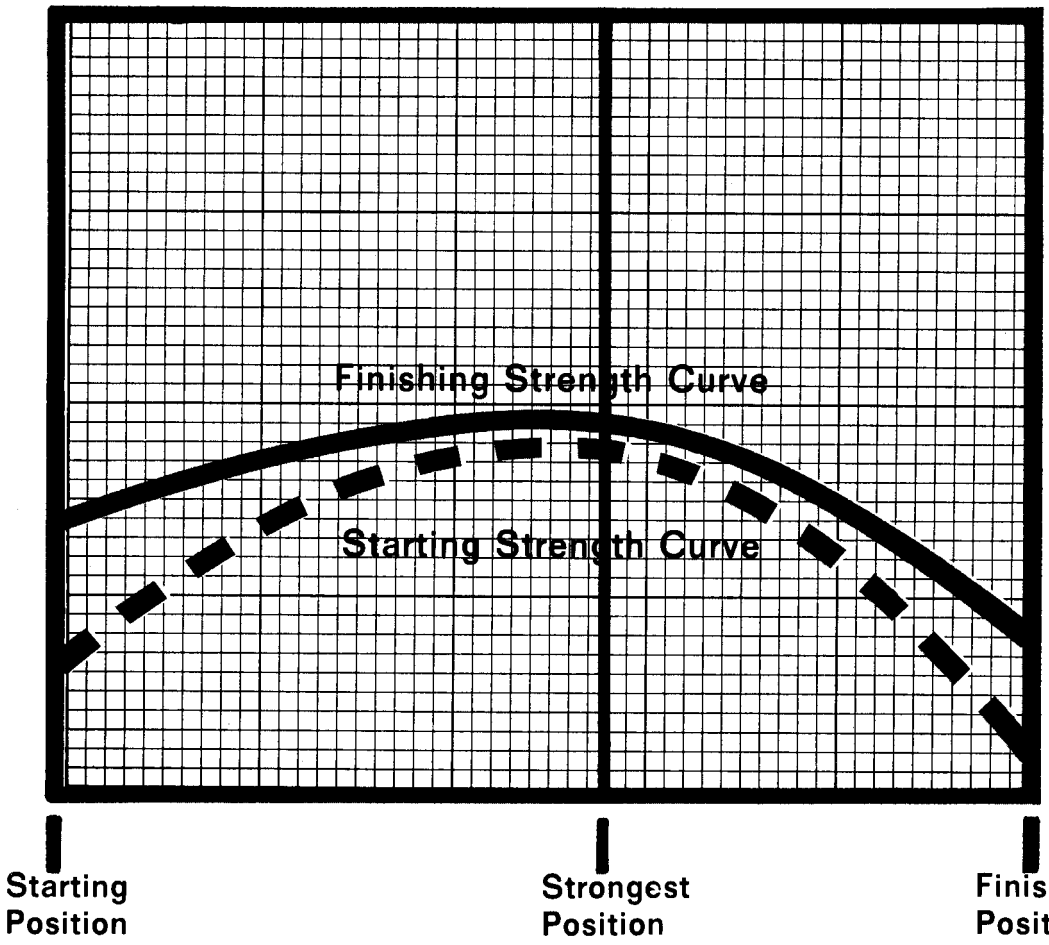
Why? Because, as a result of their previous training, they were already quite strong in the mid-range of possible movement… while being very weak near both ends of the movement; thus, when they were first exposed to a form of resistance that provided a proper variation in resistance throughout a full range of possible movement, they were limited to an amount of weight that they could handle in their weakest position. Which weight provided the proper overload in that position, while being far too light in their strongest position.

The result being that their strength in their weakest positions increased at a very rapid rate, a rate that many people consider to be impossible… while the strength in their strongest position changed very little.

These cadets were tested only at the start and at the finish of this program, so I cannot say for sure what had happened at the midway point… but I would not be surprised to discover that they had actually lost strength in their strongest position at the end of the third or fourth week.

Why? Because, up to that point they could not handle enough resistance throughout the full range of possible movement to properly overload their muscles in their strongest position, and a muscle that is not properly overloaded on a regular basis will steadily lose strength. So it could well be that these subjects were rapidly increasing their strength in some positions while slowly losing strength in one position. Then, when their weak points in the movement became sufficiently strong, they started to increase their strength throughout the full range of movement.

Illustration Number 2



This illustration clearly shows the changes in the strength curves that were produced by only six weeks of proper exercise.

When a proper strength curve has been established, at any level of strength, then additional increases in strength will be produced in proportion throughout a full range of possible movement… which, obviously, is another proof that the variation in resistance that is provided is proper for the movement. And, at that point, the resistance will feel perfectly smooth… will feel the same in every position throughout the full range of possible movement.

By the end of the program, these cadets were very close to a perfect strength curve in this exercise… thus, if the program had been continued longer, and if they had produced, for example, an additional increase in strength of twenty percent in any one position, then they would have produced an increase of approximately twenty percent in every position. And… from that point on, any increases in static strength would have been matched exactly by increases in dynamic strength. When the strength curve is proper, then any increase in static strength will be exactly matched by an equal increase in dynamic strength.

Let us assume, for this example, that you have never performed any sort of exercise in your life. You come to me and you ask me to test your strength and to train you, and I agree. As a first test, I put you into a bench-press machine with eighty pounds, and I ask you to perform as many repetitions as you can, as fast as you can. A machine is used instead of a barbell because it does not require any skill on your part, you didn't have to worry about trying to balance a

barbell… either you can lift the weight or you can't, we are testing your strength, not your skill. With eighty pounds, you are able to perform ten repetitions… and you are unable to perform the eleventh repetition.

Ten minutes later, following a rest, I test you on the same machine with ninety pounds… and this time you fail after five repetitions, are unable to perform the sixth repetition. Then, following a second rest of ten minutes, I test you on the same machine for a third time, this time with one-hundred pounds… you are able to perform only one repetition, very, very slowly, and cannot perform a second repetition. Ten minutes later I test you again with one-hundred and five pounds, and you cannot perform even one repetition… this amount of weight exceeds your existing level of dynamic strength at that point in time.

However, ten minutes later I hand you the weight in the mid-range of possible movement and ask you to try and hold it in that position… to prevent the weight from moving downwards. And you find that you can hold it in that position. You can not lift it into that position, and you cannot lift it any higher, but you can hold it motionless in that position, preventing it from moving downwards.

At this point in the testing we have established four things… your dynamic strength against three different levels of resistance, and your static strength in that particular position.

Ten minutes later we give you a final test. I hand you one-hundred and ten pounds in the mid-range position… and we find that you cannot prevent this amount of weight from moving downwards. Thus we now know that this load exceeds your existing level of static strength in that position.

This completes your pre-test… we have now determined both your existing level of dynamic strength and static strength in this movement and in that position.

Six months later, following six months of regular training on a program of exercises that included the bench-press on this machine, we decide to test your strength again. Being familiar with the progress you have shown, and knowing the amount of weight that you have been using recently in the bench-press, as well as the number of repetitions that you can perform, I am in a good position to determine the proper poundages to use in this test.

From my observations I believe that you have doubled your strength in this exercise, so I start the test with one-hundred and sixty pounds, exactly twice the eighty pounds that you were tested with at first. And I have guessed exactly right because you are able to perform exactly ten repetitions with this weight, and then fail on the eleventh… thus you have doubled your dynamic strength, performed the same number of repetitions with twice the weight.

Ten minutes later I give you one-hundred and eighty pounds, exactly twice the ninety pounds that you used for the second test six months earlier. And this time you get only five repetitions and fail on the sixth. So again you have performed the same number of repetitions while using twice the weight that you used six months earlier.

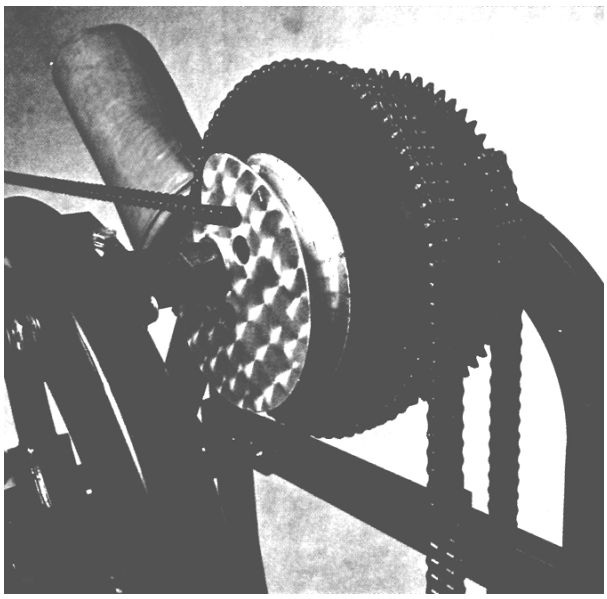
Then, ten minutes later, I test you with two-hundred pounds, and this time you can perform only one repetition and fail on the second… so again you are twice as strong as you were six months earlier. That is, your dynamic strength has doubled itself.

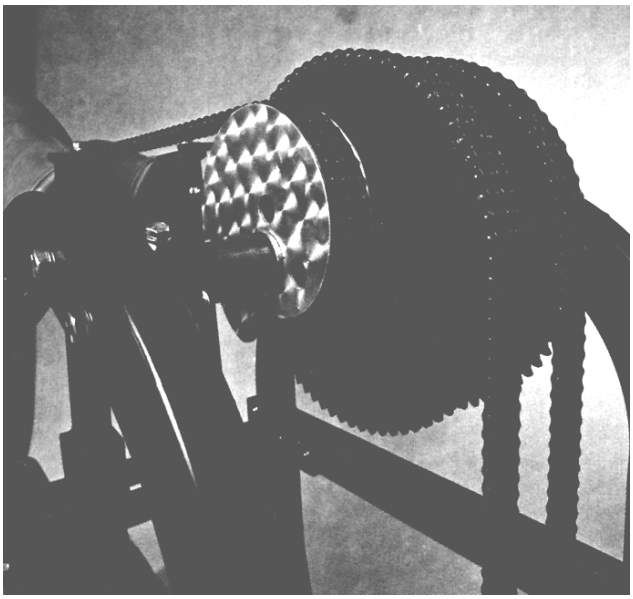
In the first test, when I gave you one-hundred and ten pounds in the mid-range position, you were unable to prevent it from moving downwards. Do you really believe that the same thing would happen now, six months later?

In order to lift a load of two-hundred pounds, you were required to produce a force in excess of two-hundred pounds in order to start the weight moving upwards… then, in order to keep it moving upwards at a steady speed, you were required to produce a force of exactly two-hundred pounds.

In fact… if you had increased your dynamic strength as outlined above, then your static strength would have increased in exact proportion. If I had then given you a load of two-hundred and ten pounds, you would not have been able to lift it… because that load would exceed your level of dynamic strength.

But… if I handed you a load of two-hundred and ten pounds in the same position, the mid-range position, where I tested your static strength with half that load six months earlier, then you would have been unable to hold it in that position, prevent it from moving downwards.





Thus it would be clearly demonstrated that your static strength had also doubled, had increased in exact proportion to your dynamic strength.

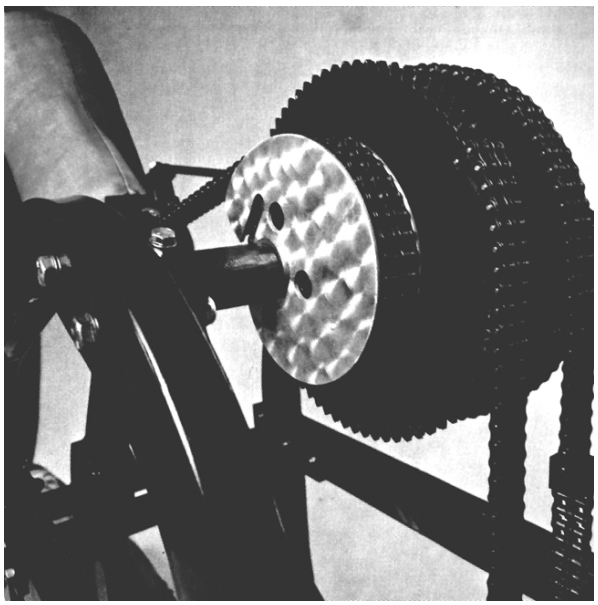
The potential results of proper exercise are probably far beyond your fondest hopes… unless you are expecting miracles; but, as they used to say on maps when they were talking about an area of the world that was as yet unexplored… "in that area are found dragons". The mafia put it another way… "If you can't lose, you can't win". And the Chinese understood the situation very well, so well that they have only one symbol for two meanings… opportunity, and danger.

All of which may be a bit of an overstatement, because the opportunities provided by proper exercise can be utilized without the necessity for encountering any of the dangers. But, at the same time it is also true that if you insist upon following the advice of some of the present crop of experts then it is highly likely that you will meet some dragons… or at least look and feel like you have.

It should be clearly understood that nothing I have said in this article is intended to convey the impression that barbell training is either dangerous or nonproductive… quite the contrary, by comparison to any previous tool designed for the same purpose, the barbell was and is almost magic; and, properly used, which it seldom is, a barbell is certainly not dangerous.

So I certainly have nothing bad to say about barbell training, but I have a great deal to say about the improper use of a barbell… or the improper use of any tool for that matter. Including the improper use of a Nautilus machine. In any real sense of the term, a Nautilus machine is nothing more nor less than an improved barbell, a logical barbell, a rational barbell; with a barbell you are lifting weights, and with a Nautilus machine you are lifting weights… the only real differences are based upon the fact that a Nautilus machine provides your muscles with the required overload throughout a much greater range of movement, and the fact that the variation in resistance that is provided by a Nautilus machine is based upon the actual requirements of the muscles themselves, rather than being arbitrarily dictated by the random variation in resistance that is provided by a barbell.

Several factors are required to produce the two categories of differences that are mentioned above, but all of those factors are provided only and simply because they are required to produce those two areas of improvement, greater range of movement and properly varied resistance.



The negative cam shown in three positions during a single repetition. Far left – starting position, middle–mid-range (sticking point, or position of lowest resistance), near left – finishing position (position of highest resistance).

For the last twelve years we have been marketing a wide variety of Nautilus machines that provide those two improvements in a manner that is as close to being perfect that any slightest imperfection is of no practical importance… the increased range of movement being provided by the overall structure of the machines, and the greatly improved variation in the resistance being provided by the cams.

During those years we have made a number of other very important contributions to the field of exercise… Nautilus was the first to point out the real value of the negative part of exercise, while a number of other people were doing everything possible to convince the public that the negative part of exercise was of no value, was dangerous… Nautilus also introduced negative-accentuated exercise, hyper exercise, infimetric exercise, and akinetic exercise, which solves the problems produced by a fast speed of movement during exercise, totally removing even the possibility of producing the kinetic energy that is otherwise involved, kinetic energy that causes the weight to "float" upwards during the last portion of a movement performed at high speed.

Which last part of that statement is not meant to imply that Nautilus is in favor of a fast speed of movement during exercise… but since nobody in their right mind even pretends to know just what is, or is not, the best speed of movement is an improvement over an exercise that must be performed at any arbitrarily selected speed of movement; this being true only when the exercise can be performed without producing kinetic energy… which it can be, in a Nautilus machine that provides akinetic features. This also being true when, and only when, the exercise does not sacrifice such things as the negative part of the exercise, or the proper variation of resistance, or a full range of possible movement; features which are provided by an akinetic Nautilus machine, but are not provided by any other type of exercise equipment.

So our progress has been almost continuous over the last twelve years, in a number of important areas, continuous and evolutionary… but perhaps not revolutionary; not truly revolutionary since 1970, since the initial introduction of the first Nautilus machines placed on the market… not, at least, until very recently, until we finally understood the actual potential of the negative cam.

But make no mistake about it, the proper application of the negative cam is nothing short of revolutionary… making it possible for the first time to design an exercise machine for a compound movement that provides all but one of the features already incorporated into Nautilus machines designed for single-axis movements.

There are at least nine requirements for a proper, full-range exercise; these requirements are…

One… rotational form of resistance, rotating on a common axis with the involved joint of the body.

Two… a direct form of resistance that is directly imposed upon the body part that is being moved by the muscles being worked.

Three… an automatically variable form of resistance that varies instantly as movement occurs.

Four… balanced resistance that varies in accordance with the actual requirements of the muscles in different positions.

Five… resistance that is provided in a stretched starting position; which requires a range of movement in the machine that actually exceeds the possible range of movement of the user.

Six… negative work potential.

Seven… positive work potential.

Eight… pre-stretching; a factor that is required during the last one or two repetitions of a set of high-intensity movements.

Nine… resistance that is provided in the finishing position of the movement, the only position of full muscular contraction.

A tenth factor may or may not be a requirement for truly proper, full range, high-intensity exercise… this being an unrestricted speed of movement. I won't argue about the merits of this tenth factor, because, as I said before, nobody in their right mind even pretends to know what the best speed of movement during exercise really is… but the other factors are simply beyond dispute.

All of the first nine factors have been provided in almost all Nautilus machines designed for single-axis movements, and the tenth factor is provided in quite a few of these same machines. But please note the above qualification… "in almost all"… I pointedly did not say "in all" Nautilus machines designed for single-axis movements; because one of those nine factors is potential dangerous in at least one movement. And, for that reason, that feature is excluded from one of the single-axis Nautilus machines… the machine being the leg-extension machine, and the feature being number five in the above list, resistance that is provided in a stretched starting position.

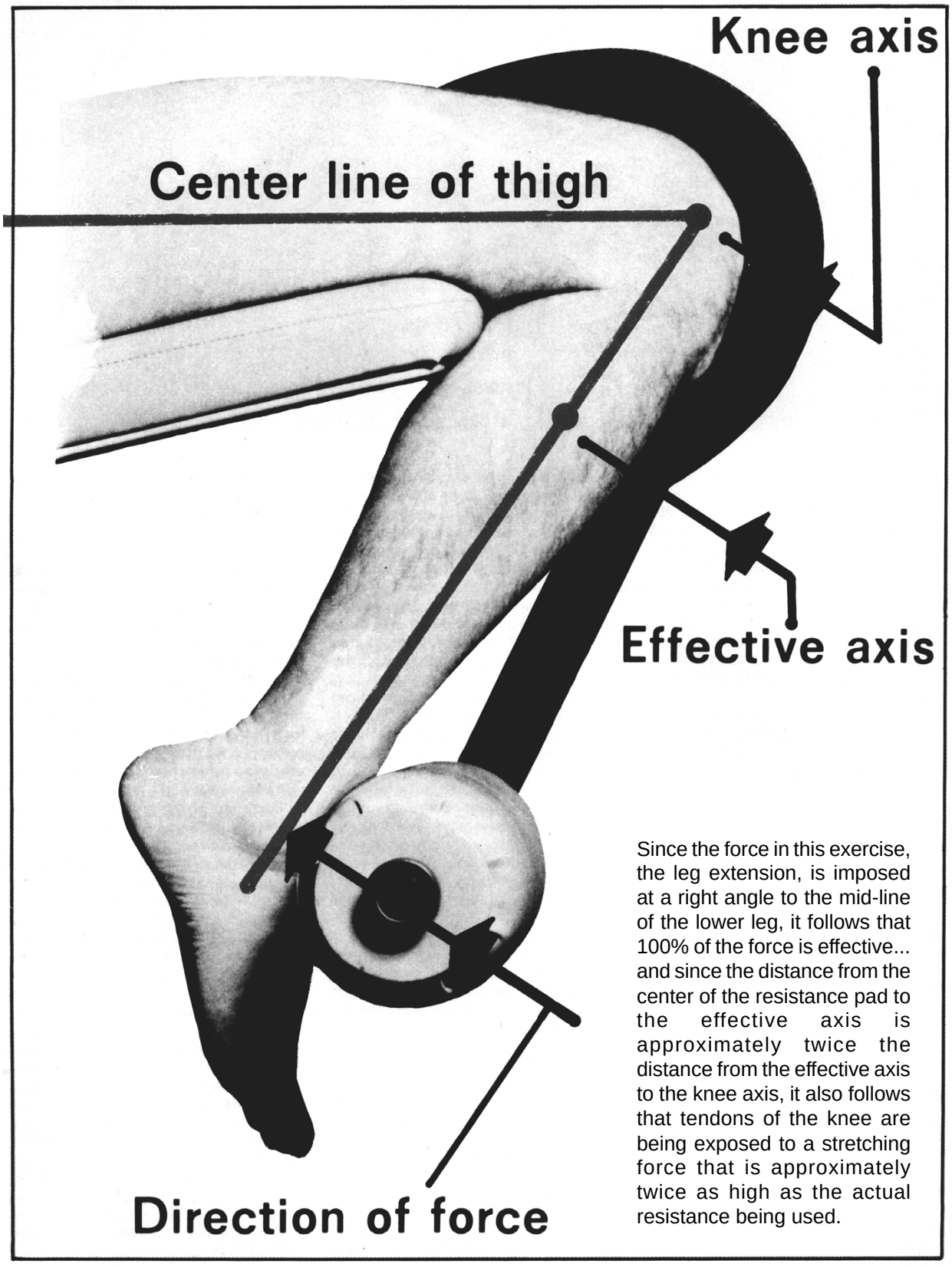
Because… in the leg-extension exercise, a truly full-range of possible movement cannot be provided in a safe manner; attempting to do so may cause damage to the knee. In that movement, when the muscle mass on the back of the calf comes into solid contact with the rear of the thigh while under a heavy load, then the effective axis of rotation can move a distance of as much as several inches; the results being that the knee is no longer rotating in a normal manner, and that the tendons of the knee are being stretched in a dangerous fashion.

So… for those very good reasons, the Nautilus leg-extension machine does not provide one of the features actually required for a truly full-range form of exercise. Stretching is fine in most movements, to a reasonable degree at least, and when it is done in a safe manner… but stretching the tendons and ligaments of the knee is neither safe nor desirable.

Years ago, a friend of mine named Fred Allman, who is now a very well known orthopedic surgeon, together with another man that I have never met, wrote and published an article that was given an almost unprecedented amount of attention in this field; an article that has been quoted many thousands of times by people who never read it in the first place, many of whom probably would not have really understood it if they had read it, and at least some of whom have lied about it because it served their purposes to do so.

Personally having a total of nine medical doctors in my family, my father, my mother, my grandfather, my brother, my sister, my uncle, my cousin, my brother-in-law, and most recently my daughter, I am certainly familiar with people in the medical profession. Having met and talked at rather great length with several thousand medical doctors over a period of many years, I am also reasonably familiar with their attitudes and opinions on the subject of exercise. Having been cut on for a rather wide variety of injuries and other problems during that same span of years, I also believe that I have demonstrated my personal faith in the skill, the ability, and the integrity of most medical doctors.

And, if it were necessary to have one of my knees cut open for any reason, my first choice as a surgeon in that case



Since the force in this exercise, the leg extension, is imposed at a right angle to the mid-line of the lower leg, it follows that 100% of the force is effective... and since the distance from the center of the resistance pad to the effective axis is approximately twice the distance from the effective axis to the knee axis, it also follows that tendons of the knee are being exposed to a stretching force that is approximately twice as high as the actual resistance being used.

would certainly be Fred Allman. So it should not be assumed that anything I have said, or am about to say, in any way indicates a poor opinion of medical doctors in general or Dr. Fred Allman in particular, because that is certainly not the case.

However, having said all that, it does not follow that I always agree with some of the stated opinions of some medical doctors, and it does not follow that I am in full agreement with the opinions that Dr. Allman stated in his article a number of years ago.

The particular article that I am talking about was critical of the squat as an exercise, and pointed out the fact that a squat to the low position could cause damage to the knees… damage very similar in nature to the damage that can possible result from doing leg-extensions with an extreme range of movement.

And… while I am certainly aware that it is possible to hurt yourself as a result of doing squats incorrectly, I am also aware that the squat is undoubtedly the single most productive exercise known to man at this point in time. When it is performed properly. As it seldom is.

Primarily productive, I believe, because of the fact that the squat involves a far greater mass of muscle than any other exercise you can possibly think of; involving, as it does, the largest and most powerful muscles in the body, the buttocks, plus the large muscles of the frontal thigh, plus the muscles of the lower back, as well as quite a number of other muscles that you are possibly not even aware of.

Because of the sheer mass of the muscles that are involved in the squat, and the resulting fact that you need to use a far greater than average amount of resistance to overload these muscles properly, it rather naturally follows that the squat has never had the reputation of being an easy exercise… in fact, properly performed, the squat is undoubtedly the hardest exercise that you will ever find. The hardest, and the most productive.

But… it is my personal opinion that the article that Fred Allman wrote about the dangers of the squat was given such widespread attention primarily because it afforded a large number of people an excuse to avoid squats; an excuse to avoid an exercise that they were simply too lazy to perform. And, I must admit, the squat is certainly not a lazy man's exercise of first choice.

On the other hand, if you are not lazy, and if you are interested in producing a fast rate of progress as a result of exercise, then the squat certainly has a great deal of value to offer. But again… remember what the Chinese say about the relationship between opportunity and danger.

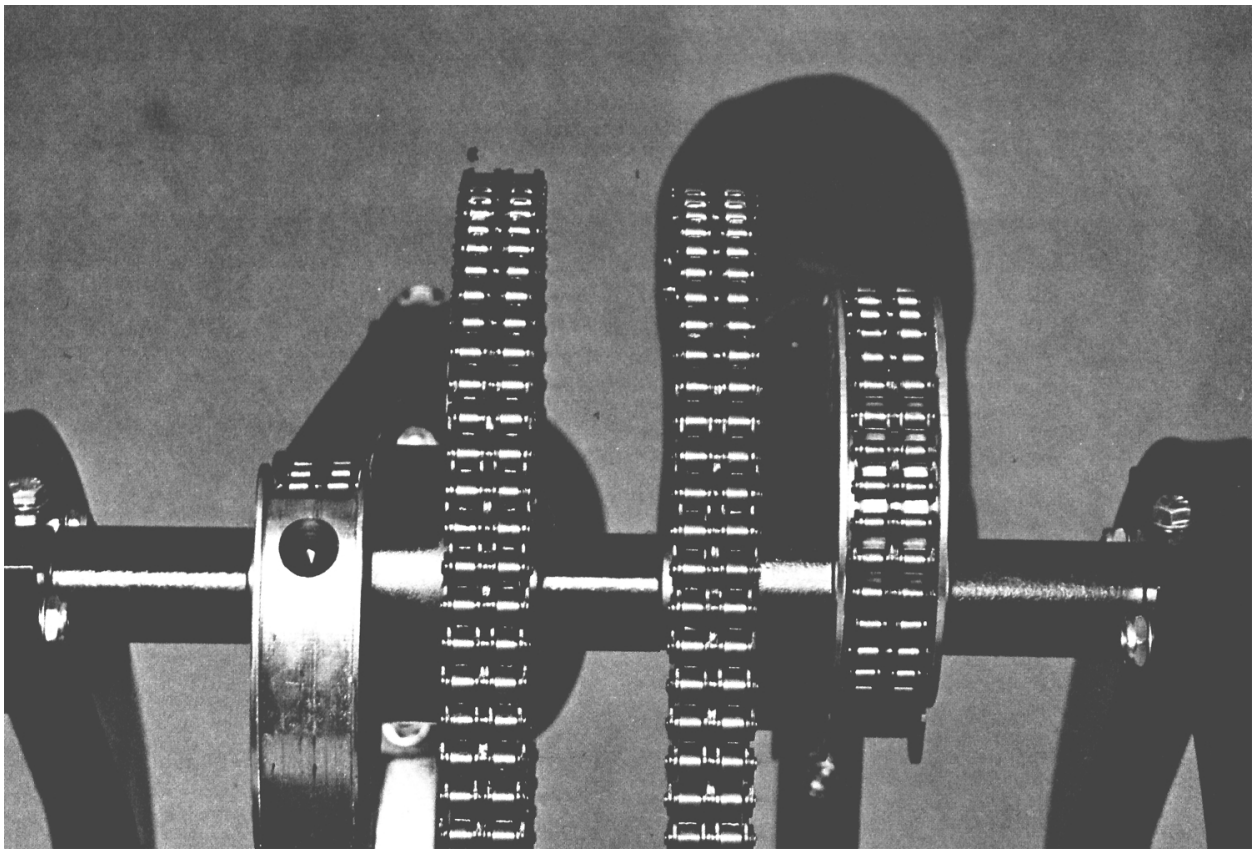
The problem then became one of attempting to realize the potential opportunity while simultaneously avoiding the potential danger; and this is a problem that has been given a rather large share of my personal attention for a period of at least twelve years, and a somewhat smaller share of my attention for about thirty years before that. A problem that until recently I did not believe could be solved in a really practical manner.

But… even though I was convinced that this was really a problem that defied solution in a satisfactory manner, I was also convinced that the potential benefits justified a continuing search for a solution. Thus, over the years, we approached the problem from every possible position that we could think of… as well as quite a number of positions that proved to be impossible.

Three distinct but interrelated problems were involved… one, since the strength cures in a squat is so complex, it appeared to be impossible to vary the resistance properly… two, since the movement of the feet during a squat is in an approximately straight line, although this "straight" movement is a resultant of rotational movements around three points, and since it was essential to produce this straight-line movement with a machine that was in fact rotational, the exact design of the moment-arms of the machine was critical… and, three, the torque of the moment-arms had to be transmitted properly to the weight stack.

And all of these things had to be done in a simple, straightforward, reliable and safe manner while keeping the friction to an absolute minimum.

To say nothing of the fact that the machine had to be easy to get into and safe to get out of… no small problem in itself



The variation between the negative cams in the mid-range and finishing positions as shown above is several hundred percent, compared to that of a single-axis positive cam, which is 50 percent or less.

when you think about the range of movement involved in a full squat. Remember, with a barbell, you start a squat in the top position… and you don't forget that first you had to get the weights up into that top position.

And… when you finish a barbell squat, you put the weights back onto a rack, again in the top position. Or at least you should, and you may well be in trouble if you can't. Did you ever get stuck in the low position of a barbell squat with 500 pounds on your back and no spotters? Lots of luck.

But, pray tell me, just how did you lift the 500 pounds into the top position of a machine? Before you start the exercise. So that you can get into the machine.

And when you have finished the exercise, what happens if you are exhausted and cannot get the weight back up into the top position? Then how do you get out of the machine, with both knees shoved back alongside your ears and a load of several hundred pounds wedging you into that position like a big sardine in a small can? With no oil.

Blood does not make a satisfactory lubricant, particularly your own blood. Which point you may learn very quickly if you ever do find yourself stuck in the low position of a deep squat with a 500 pound barbell on your shoulders.

Solving the problems involved in designing a proper squat machine has a great deal in common with flying a helicopter… it looks easy until you try it yourself, but you quickly learn that it is just damn near impossible. If the passengers in a helicopter could read the mind of the pilot then there would be very few passengers, and no sane ones at all.

A helicopter is capable of doing things that are simply impossible to accomplish in any other manner… but it is also the most dangerous machine that anybody ever stepped into. So the squat as an exercise has a lot in common with a helicopter; the squat is capable of producing results from exercise that are simply impossible in any other manner… and it is dangerous as hell.

Billions of dollars in expenses and millions of hours of work and research have so far failed to produce a really safe helicopter… so we use the ones we have, when we simply must, and we pray a lot.

But about forty years ago of very serious thought on the subject, a few thousand hours of work and several dozen prototypes finally did solve the problems related to the squat. We not only preserved the productive capabilities of the squat but we enormously improved them… while removing all of the dangers.

It is my carefully considered opinion that the new Nautilus Duo Squat machine provides the most productive exercise in history, by far. So far that it is simply impossible to reasonable compare the exercise provided by this machine with any other exercise known to man. Thanks to the negative cam.

And just what is a negative cam? A negative cam is what gives us the ability to properly vary the resistance during a compound exercise such as a squat with literally none of the apparently impossible problems associated with positive cams, or levers, or anything else you can possibly think of.

A normal cam, a positive cam, varies the resistance during exercise by changing the radius as it turns, thereby changing the lever, thus increasing or decreasing the torque. So… with a positive cam, the weight remains constant while the lever and the torque are constantly changing as movement occurs. And the torque goes up or down in exact proportion to changes in the lever. The larger the radius of a positive cam, the greater the torque, and the higher the resistance… the smaller the radius, the lower the resistance.

Which is all you need to design a perfect exercise for a single-axis movement such as a curl… provided you know the proper shape for the cam, as well as a few dozen other necessary bits and pieces of required information, since the cam cannot operate in a vacuum.

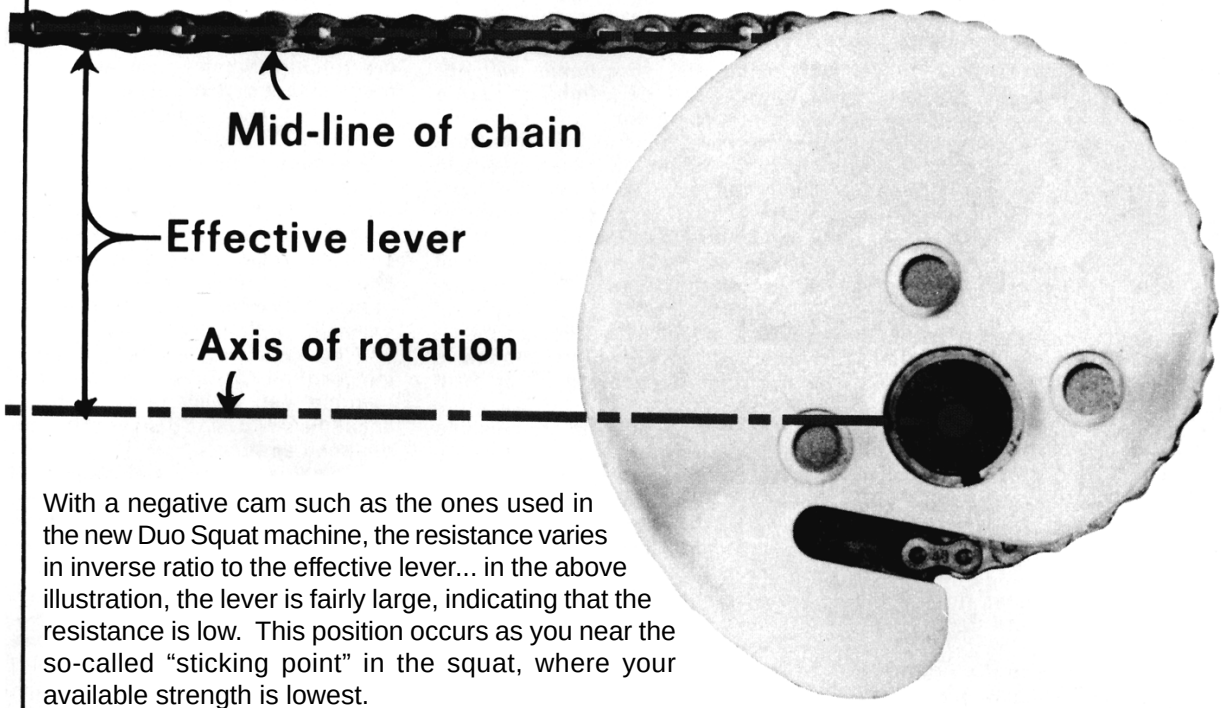
A positive cam can easily and properly vary the resistance in any single-axis exercise… but a positive cam cannot even begin to vary the resistance properly in a compound exercise such as the squat. Why? Because the resistance varies so much and so quickly that it is simply impossible to design a positive cam with the required shape. Not difficult, impossible.

When you start up from the low position of a full squat, your strength is fairly high, so you need a lot of resistance… but as you move upwards you grow steadily weaker, a lot weaker, so the resistance must be reduced in exact proportion to your decreasing strength… then, when you reach the so-called “sticking point”, your strength is at its lowest level, so the resistance must be low at this point… but when you have passed the sticking point on your way up, your strength starts to increase very, very rapidly, and continues to increase throughout the rest of the movement, so the resistance must also increase in exact proportion, must increase several hundred percent in a very short distance. The unavoidable result being that you are forced to lift an amount of weight that you can handle in your weakest position… which is nowhere near enough resistance in your strongest position.

A positive cam designed to provide that pattern and degree of variation would look a lot like an enormous banana… and the functional parameter would have a concaved shape. Which is an obvious contradiction of terminology… because, if the perimeter had the correct shape, then it wouldn’t be functional, could not be functional.

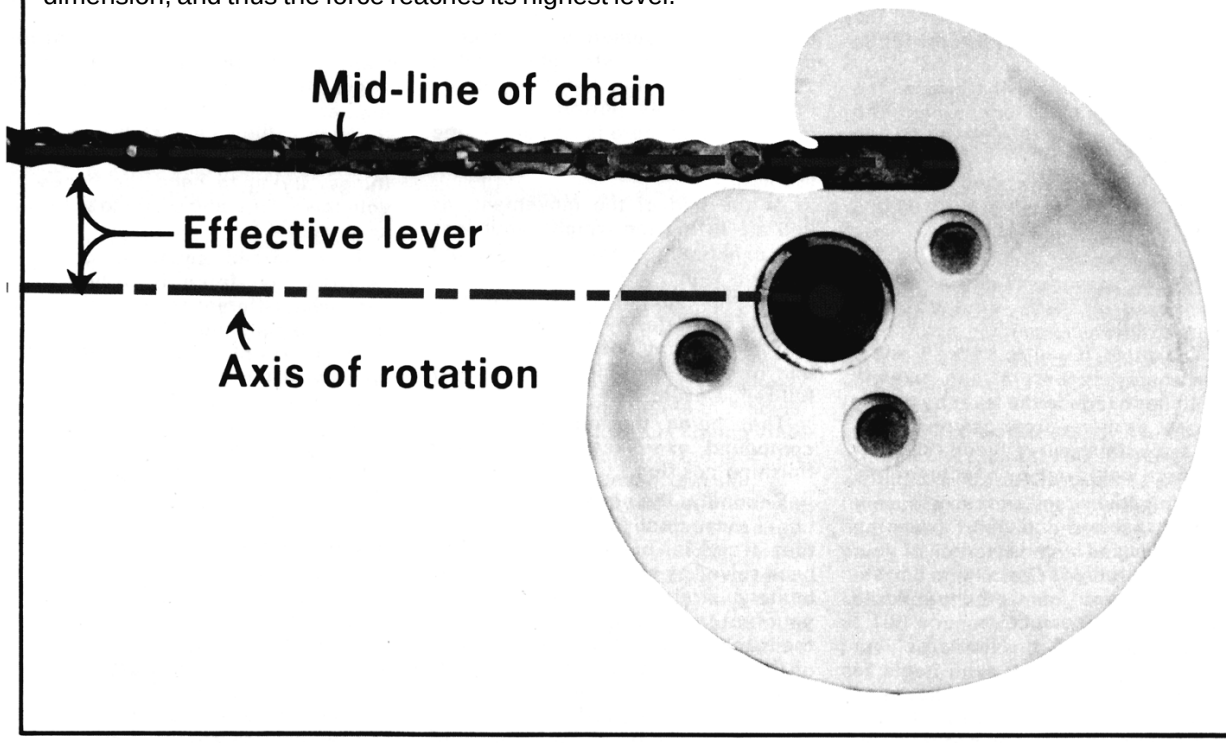
The basic problem with a positive cam in this application stems from the fact that a positive cam varies the torque by changing the lever… and the required resistance in a squat increases so rapidly and to such a point that it is impossible to increase the radius of the cam to the required degree while maintaining a functional shape.

But a negative cam does not vary the torque… instead, it maintains a constant level of torque while changing the force in inverse proportion to the radius of the cam.



With a negative cam such as the ones used in the new Duo Squat machine, the resistance varies in inverse ratio to the effective lever... in the above illustration, the lever is fairly large, indicating that the resistance is low. This position occurs as you near the so-called "sticking point" in the squat, where your available strength is lowest.

In the illustration below, the cam is shown in its position of highest force... the locked-out finishing position of the squat. In this position, the lever reaches its smallest dimension, and thus the force reaches its highest level.



If you could design and build a positive cam that was capable of providing the proper degree of variation in resistance required in a squat, which you could not… then the size of the cam would be utterly ridiculous. Worse than that, it would be outrageous.

If a positive cam that was capable of providing the required torque was mounted on the axis of the moment arms of our new squat machine, then the radius of that cam would have to be approximately seventy inches… nearly six feet, and that is the radius, not the diameter… which, among other things, would mean that the machine would be about eleven feet tall. But the radius of the negative cam that we use in our new squat machine is only a few inches… in fact, this is one of the smallest cams we ever used.

With a positive cam, the resistance rises in proportion to the increases in the size of the radius… but with a negative cam, the resistance rises in inverse proportion to the size of the radius. With a positive cam, larger is heavier… with a negative cam, smaller is heavier. A positive cam winds… a negative cam unwinds.

The smaller the radius of a negative cam becomes, the higher the force rises… and apart from the limitations imposed by the structural strength of your materials, there is literally no limit to the force that you can produce with a negative cam. LITERALLY NO LIMIT.

If you had a sprocket with a radius of ten inches, and if you suspended a weight of 100 pounds from one side of the sprocket, then you would produce a torque of 1,000 inch-pounds. Torque being determined by multiplying the "lever", in this case the radius of the sprocket or 10 inches, by the weight of 100 pounds; 10 inches times 100 pounds giving us 1,000 inch-pounds of torque.

Now… if you did not want the sprocket to turn, and if you prevented it from turning by hanging a chain from the opposite side of the sprocket and attaching this chain to the ground, and if you had a "pull type" scale inserted into the chain… then it would be obvious that you were producing 100 pounds of force on this chain. And the scale would read 100 pounds.

But if, instead of this, you had a second, smaller sprocket bolted to the first sprocket, this smaller sprocket having a radius of only five inches, and if you wanted to stop the larger sprocket from turning by anchoring the smaller sprocket to the ground… then your scale would show that you were now producing a force of 200 pounds.

Remember, torque is a resultant of two factors, lever and force… thus, if the torque remains constant, and if you reduce either of the two factors, then the other factor will increase in proportion.

In this case, by using a smaller sprocket, we reduced the lever from ten inches to only five inches, thus increasing the force from 100 pounds to 200 pounds.

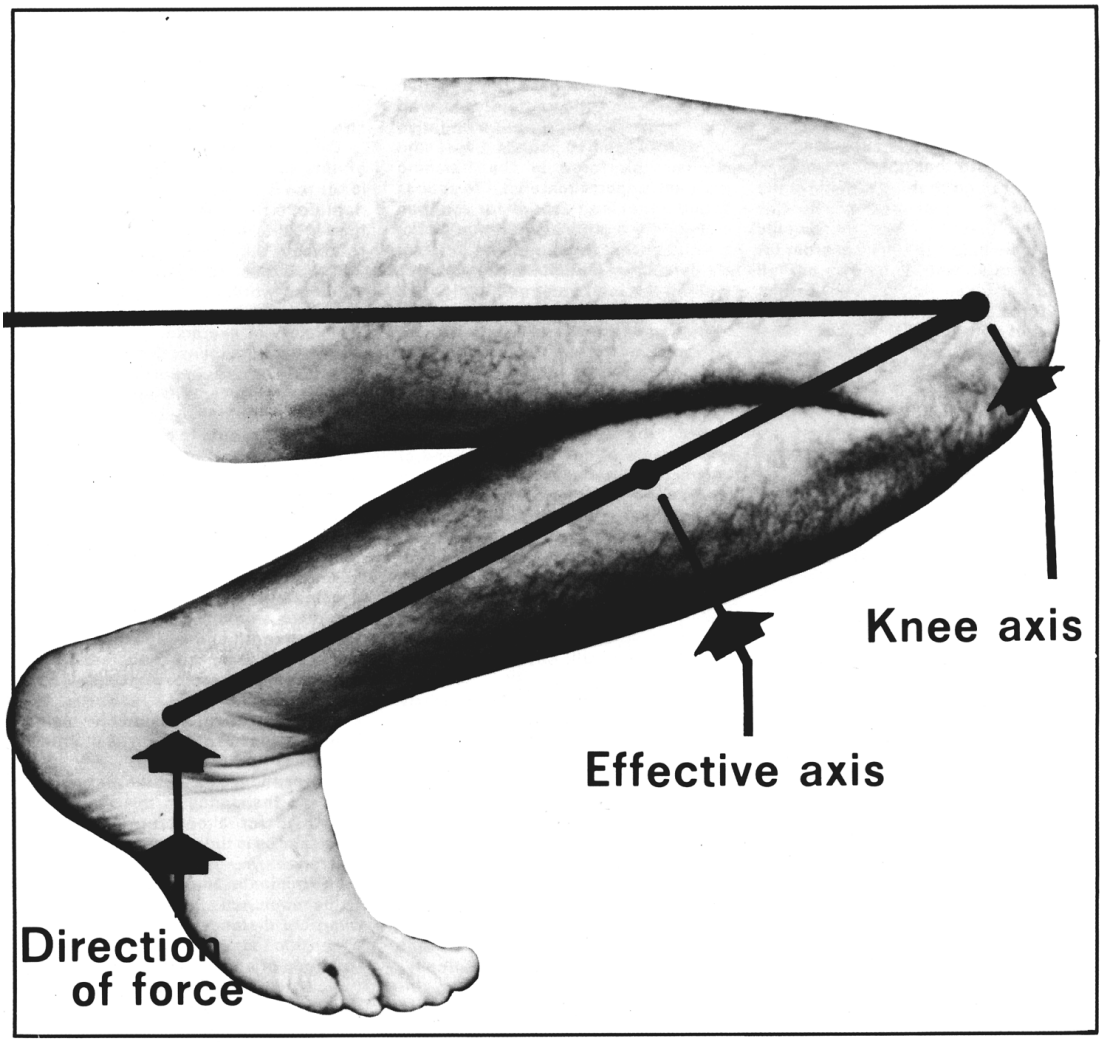
And just what does that prove about a near infinite force? Just watch. What if I remove the smaller of the two sprockets and replace it with an even smaller one, a sprocket with a radius of only one inch? Then our lever would be only one inch… and, since we still have a torque of 1,000 inch-pounds, our force would be 1,000 pounds.

The more we reduce the lever, the higher the force rises. Just how far do you want to go? If we then reduce the size of the one-inch lever by ninety percent, the result will be a force of 10,000 pounds. And if we reduce that by ninety percent, the force will rise to 100,000 pounds. And, of course, if we reduce that by ninety percent, then we will be producing a force of 1,000,000 pounds… literally a million pounds.

You could, if you so desired, and if your materials were strong enough, continue to reduce the lever by ninety percent as many times as you liked, and each time you reduced the lever the force would rise by a factor of ten.

A negative cam works in a very similar fashion, and apart from the limits imposed by the strength of your materials, there is literally no limit to the force you can produce while using a negative cam. You will reach the limits of your body long before you even begin to approach the limits of a negative cam… a negative cam can literally give you all the force you can tolerate, a billion times over, and still not even begin to approach its own limit. It has no limit.

But, you do… and while it is certainly true that your strength is very high near the top position of a squat, it is also true

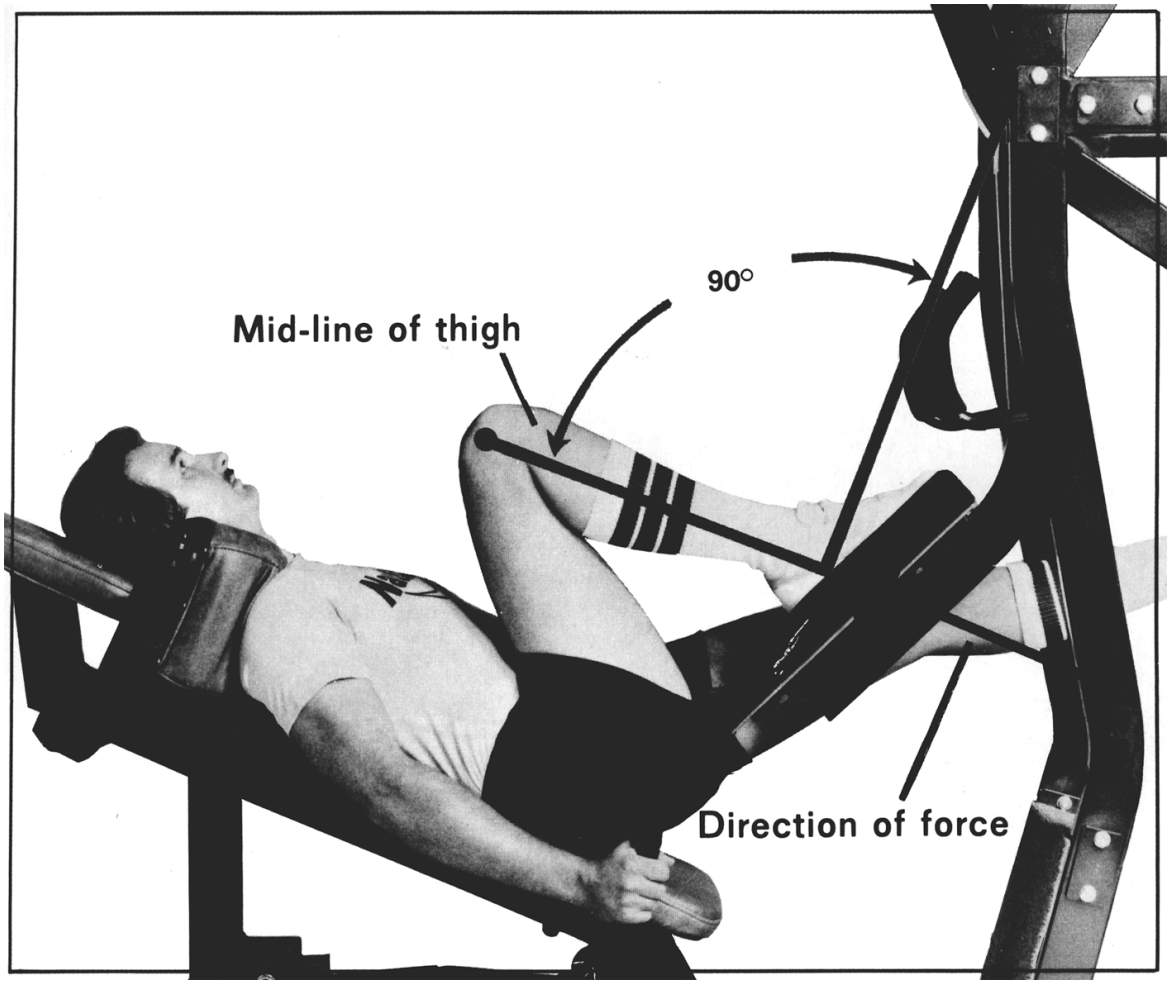


In the low position of a full squat, the force is imposed from a different direction, but the effect is much the same. In the above illustration, the force is imposed at such an angle relative to the mid-line of the lower leg that it is approximately 87% effective... which means that approximately 87% of the weight of the barbell, plus the weight of the man, is trying to bend the man's lower leg.

In this case, assuming a 200 pound man and a 300 pound barbell, 87% of 500 pounds is trying to stretch the tendons of the knee.

While the direction of force involved in the squat is less effective than it is in the leg-extension, the amount of force is much higher; so the effect is much the same in either case... but the danger to the knee is greater in the squat since the total of the effective force is higher.

And again we have a similar situation to that involved in the leg-extension... since the distance from the point where the force is imposed to the effective axis is greater than the distance from the effective axis to the knee axis, it follows that the forces trying to pull the knee apart are actually a lot higher than the total force imposed.



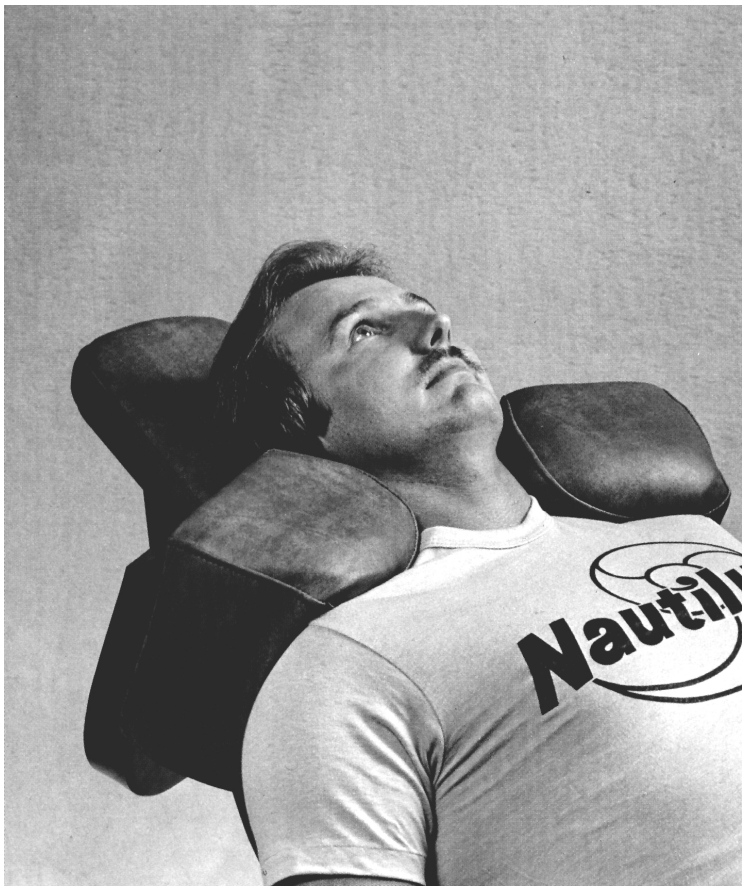
In the low position of the squat performed in the new Duo Squat machine, the direction of the force is different from that involved in either a barbell squat or a leg-extension.

In the above illustration, the force imposed from such an angle that it is in line with the mid-line of the lower leg. In this example, the force is imposed from such an angle that none of the force is trying to bend the leg.

In a barbell squat that went into the same low position, the force would be approximately 70% effective.

that your bones will not support an infinite weight, or even a near-infinite weight. So we designed the negative cams in the new squat machine with this limitation clearly in mind… the result being that the maximum force, using the entire weight of 510 pounds, is approximately 1,174 pounds as you reach the finishing position of the squat; which is approximately equal to doing the last part of a barbell squat with 1,000 pounds… and which amount of resistance is enough for anybody short of Paul Anderson.

As you move close to the finishing position of a squat, your muscles are given an enormous advantage of leverage, and even a man of average strength can rather easily perform the last part of the squat with a weight of 1,000 pounds… if his bones can stand the load. But he had better not make the mistake of bending his legs very far under that kind of a load because, if he does, he will not be able to stop the downwards movement and will hit the floor so fast and so hard that he will no longer be even slightly interested in exercise, or anything else for that matter.



The head and shoulder pads of the Duo Squat machine. The shoulder pads are made of soft, solid foam, brush cut and formed to fit the contours of the shoulders for comfort.

But you will not encounter that sort of problem in our new squat machine, because the resistance will instantly and automatically change in proportion to your strength in every position… there is no "sticking point" in the squat as performed in this machine… and there is no point in the movement where the resistance is too light.

At the end of the movement, as you are lifting the weight, your legs will eventually reach a locked out position where the resistance is removed from your muscles and is then entirely supported by your bones… thus it is simply not possible to provide one of the requirements for a truly full-range exercise. That being the nature of most compound exercises, a locked-out finishing position.

Secondly, the squat is not a rotational movement in the same sense that a curl is; but this problem has been solved by converting the approximately straight-line movement of your feet to a rotational movement of the machine in such a manner that all of the benefits of a rotational movement are achieved while any potential problems are avoided… so we have the best features of both types of movements and the problems of neither.

Problems in a rotational movement? What problems? There are no problems in most single-axis, rotational movements… but don't forget what I said about the problem that can be caused by trying to do a full-range leg-extension exercise. Because of the way the lower leg comes into contact with the back of the thigh when the leg is bent to its limit at the knee… and because of the direction from which the resistance is imposed in that exercise… it is dangerous to perform a full-range leg-extension with a heavy load. Which is almost exactly the same danger that Dr. Fred Allman was pointing out in his famous article about the squat… the danger of pulling the knee apart. Which is a very real danger in barbell squats, and the reason that powerlifters do not go any lower than a position where their thighs are parallel with the floor.

But… because of the design of the new Nautilus Duo Squat machine, this problem is removed; there is very little if any force in the direction that is responsible for causing this problem with the knees. In the very low position of the squat in this machine, the forces on the knees are acting in a different direction from the forces that are dangerous to your knees in a barbell squat. In a full-range leg-extension movement, the force is acting at a right angle to the bones in your lower leg… and when the back of your calf touches solidly against the back of your thigh, the force is doing two things; trying to bend the bones of your lower leg… and trying to pull your knees apart.

In a barbell squat, in the low position, the force is acting at a somewhat different angle… in this case it is no longer imposed at a right angle to the bones of your lower leg; but it is still doing the same two things… trying to bend the bones of your lower leg, and trying to pull your knee apart. The direction of the force is much worse in the leg-extension exercise than it is in the barbell squat… but the amount of the force is much greater, and thus worse, in the squat; so the result is much the same in either case.

But… the situation is entirely different in the new Nautilus Duo Squat machine; because the force is imposed from a much different direction in the low position of the squat, regardless of how low you go. In this machine, in the low position, the force is imposed IN LINE with the bones of your lower legs… thus the force is not trying to bend the bones of your lower legs, nor is it trying to pull your knees apart.

If your flexibility is such that you can move into that position, and if you want to go that low, it is literally impossible to squat so low in this machine that your buttocks would have to be below the floor in order for you to squat that low with a barbell… and yet, even in that low position the force remains in line with the bones of your lower legs.

The danger in a full squat, a low squat, is not a result of the position of your legs in relation to your torso… the danger is a result of the direction from which the force is imposed.

Scratch one more danger off the list of problems involved in barbell squats, while adding a range of movement that is impossible with a barbell. Impossible unless you want to perform your squats while standing with your back on the edge of a cliff… so that you will have someplace to put your buttocks instead of trying to shove them through the floor.

And the other problems? The machine is entered in the midrange of possible movement, so if you are flexible enough to sit down in a chair then you can get into this machine with the greatest of ease. Getting stuck under a heavy load in the bottom position? Impossible, because the full-range squat is performed one leg at a time… and in the event that you could not move the working leg out of the low position, you would simply bend the other leg and the weight would instantly be removed from both legs.

Bending your back under a heavy load? Perhaps not impossible if you really tried, but damned difficult; because the back is solidly supported against a strong, flat, comfortable surface… in such a manner that bending the back is no longer a consideration.

Falling either forwards or backwards as a result of losing your balance? Impossible.

Oh, you don't like doing your squats one leg at a time? Why not, there are several advantages and no disadvantages? But if you just must do them both legs at the same time, then you can easily perform normal, parallel position squats with both legs at the same time… without sacrificing any of the advantages of the automatically variable resistance that properly loads your muscles right up to the point of lock-out.

Five hundred and ten pounds of weight won't be enough in that case? Don't bet on it until you have tried it… remember, we have the negative cams working for us here; just wait until you experience what a negative cam can do to 510 pounds. Like I said earlier, the force in the finishing position is approximately 1,174 pounds… and if that isn't enough for you then your name is probably Paul Anderson.

And… even if your name is Paul Anderson, this machine can still give you all the load you can handle, and then some. Because we have added the feature of akinetic exercise to this machine… which simply means that you will be instantly provided with literally any level of resistance that you can handle… and which also means that you can perform the

movements at any possible speed of movement without producing so much as an ounce of kinetic energy… which means that the weight will never "float" upwards as a result of kinetic energy created by a sudden movement, regardless of how fast you move.

And, of course, this feature does not involve any of the gross sacrifices involved with any form of isokinetic exercise… you still have the negative part of the work, you still have the same automatically variable, properly balanced resistance throughout a full range of possible movement, you still have stretching, you have it all. No sacrifice, no kinetic energy, no problems as a result of fast movement.

Accommodating resistance? Of course… except this machine actually provides accommodating resistance. Select your own level of failure and then go at it, the machine will automatically meet any level of force that you exert, instantly and automatically, during both the positive part of the movement and the negative part of the movement.

Every single repetition from the first to the last can be a maximum possible effort… if you can produce 5,000 pounds of force during the first repetition then you will have 5,000 pounds of resistance, instantly, automatically, exactly. Then, if you can only produce 4,500 pounds of force during the second repetition, that is the level of resistance that you will have… and so on, right down to the level of force that you have preselected as your point of failure. Not that I really believe that many, if any, people will be able to produce those levels of force… but if you can, the machine will accommodate you.

And if you want to carry it to really extreme lengths, then you can preselect a level of resistance so low that you literally won't be able to stand up after you finish the exercise… you can work yourself quickly down to a point where moving your legs will be impossible, a zero level of strength.

One of the most important features of this machine is the fact that it loads the muscles of the frontal thigh right up to the point of lock-out… and this means that the parts of the quadriceps that are the most important for the purpose of stabilizing the knee are being worked properly in a compound movement for the first time in the history of exercise.

And, as it happens, this part of the muscles is very important for the purpose of preventing injuries, particularly in football.

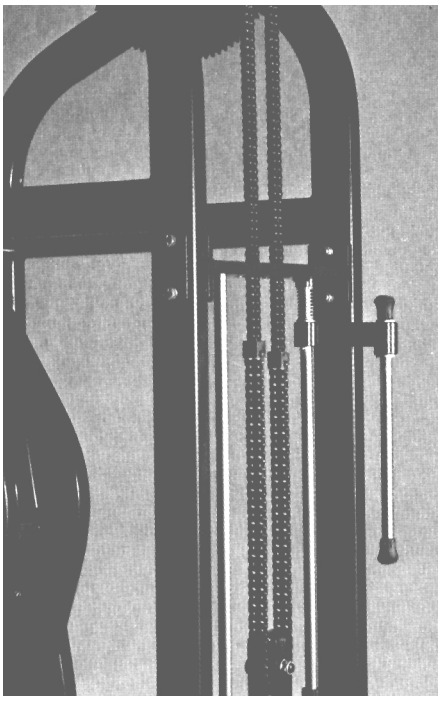
But the benefits to be derived from this machine are not limited to the quadriceps… quite the contrary, equal benefits will be produced in the strongest muscles of the body, the buttocks, in the thigh biceps or hamstring muscles, in the lower back muscles, and in a number of smaller muscles. And, as a means of gaining overall bodily strength and bodily mass, muscular body mass, this machine is by far the single best exercise device ever produced.

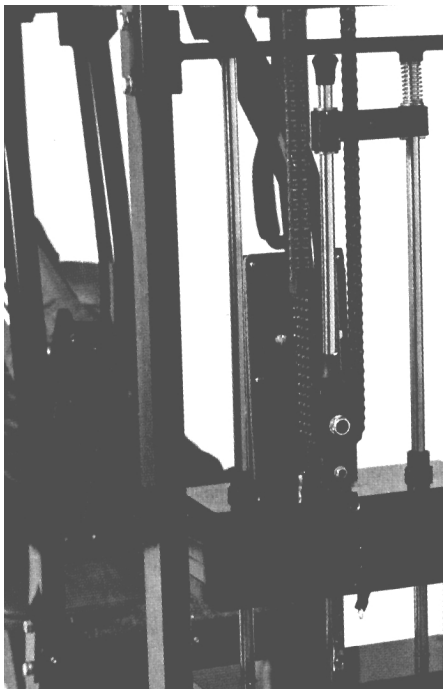
But what about women, or men who are not as strong as Paul Anderson? As I mentioned earlier, the maximum available resistance in this machine is enough for almost literally anybody… and so is the minimum available resistance. The minimum amount of resistance in this machine is 35 pounds, moving a vertical distance of approximately fifteen inches; which means a total work load of approximately forty-four foot-pounds… a load so low that almost literally anybody can use this machine properly.

Just how low? Equal to the work performed by the average person when they curl a barbell weighing 22 pounds… which is less than the weight of most bars, with no collars and with no weights. Equal to the work performed by a woman weighing 66 pounds when she steps up onto a curb from the street.

And the force? At its highest level, as the legs reach a locked-out position, the force is approximately 80 pounds… the same force that is imposed upon her body by gravity when a woman weighing 80 pounds is standing still. Earlier in the movement, in your weakest position, the force is less than 30 pounds.

In August of 1982, Nautilus began a study that will last for at least ten years, in cooperation with the School of Medicine of the University of Florida… a detailed study into the effects of exercise on older women suffering the effects of osteoporosis. Osteoporosis is a condition resulting from degeneration of the bones, a situation which literally destroys the strength of the bones, rendering them incapable of supporting even the weight of the person suffering from this condition.





Above: The moulded foot pads are extra long with raised sides and contoured heel rests for ease in positioning the feet properly.
Right: The akinetic bar, in the neutral position, permits use of the machine in a regular fashion.
Bottom right: The akinetic bar in use. This position permits the user to work at any speed with any weight up to maximum with absolutely no production of kinetic energy.

The women taking part in this study will be trained on the new Nautilus Duo Squat machine as well as a variety of other Nautilus machines… women that are already suffering the results of osteoporosis.

Another long-range study is being conducted using pregnant women as subjects, and these women are also being trained on the new Duo Squat machine. As I said, the minimum resistance available in this machine is low enough for almost literally anybody.

Two versions of the new Squat machine are available… both versions being identical in every respect except two; one version has a weight stack of 410 pounds, which is more than enough resistance for all but the strongest men… the other version has a weight stack of 510 pounds,

plus an additional feature which permits the performance of akinetic work.

The potential benefits of the Duo Squat machine are not limited to the development and muscular strength and size… since this machine also provides the best possible source of cardiovascular benefits. Not "one of the best sources"… THE BEST POSSIBLE SOURCE OF CARDIOVASCULAR BENEFITS. And, probably the safest.

Too strong? An overstatement? Don't be too quick to judge… literally anything that can be accomplished by any type or amount of running, or any type of stationary bicycle riding, can be accomplished on this machine; all of the benefits, and then some… and none of the problems.

With the use of the akinetic device incorporated into this machine, it is possible to preselect a work-load of almost any desired level, high or low, or in between… then the exercise can be performed at any desired speed of movement, from very slow to the fastest speed of movement that is possible while working against the selected work-load.

Without producing even the slightest amount of kinetic energy, without causing the weights to "float" upwards as a result of kinetic energy produced by fast movement. Without the pounding that unavoidably is involved in any form of running or jogging. Without the sacrifice of the negative part of the work that is involved in any form of isokinetic exercise. While providing exactly the desired range of movement… from a full range of possible movement to a very limited range of movement if this is desired.

The normal "lock out" that occurs at the end of a full movement in this machine can be utilized or avoided, as you choose. If you desire to avoid the locked-out position, for whatever reason, then it is only necessary to adjust the seat slightly and a locked-out finishing position becomes impossible.

With the use of any one of a wide variety of readily available pulse monitoring devices, it becomes easily possible to utilize this machine for cardiovascular improvement while keeping your pulse very, very close to any desired level.

You are using the same muscles in this machine that are involved in either running or bicycle riding, but you are using a far larger part of those muscles because of the much greater range of movement… which means that you will get even better cardiovascular benefits while increasing both your strength and your flexibility at the same time, results that are denied you by running or bicycle riding.

With all of the problems, and with all of the dangers… the barbell squat has certainly been the most productive exercise in history; but it isn't anymore… beyond any shadow of a doubt, the single most productive exercise is now provided by the new Duo Squat machine from Nautilus.