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Distance – Resistance – Speed…
The Real Basis of Exercise

"How much can you press?" is a totally meaningless question, unless you also ask, "How far do you press, and how fast do you press?"

Strength is the ability to produce power; and while we cannot measure strength directly, we can measure the amount of power being produced, but to do so, three factors must be considered. These are: the amount of resistance involved, the distance it is moved vertically, and the time factor. Thus the ability to press more weight than another man can handle does not necessarily indicate that you are stronger than he is; not, at least, unless both of you press the same distance, and in exactly the same time.

If one man presses 275 pounds a distance of two feet in one second, then he is producing one horsepower; although the second man used exactly twice as much time to press it an equal distance and thus the strength of the two men is equal.

Why have I chosen this example from basic physics? Because, during a recent telephone conversation with Mr. Peary Rader, the publisher of Ironman Magazine, the point was raised that quite a number of people apparently do not understand the basic physical principles upon which the new Nautilus training equipment is based; and since it is perfectly normal for people to have doubts about something which they fail to clearly understand, this article is hopefully intended to establish just such clarity and understanding – even in the minds of people with no background in physics at all. For that reason this is being written in non-technical terms.

Taken point by point, in a simple, straightforward manner, the basic laws of physics of importance in the field of exercise should be understood to most anyone; and without such an understanding, training progress becomes a matter of "hit or miss" in all cases, and in most cases far less than optimum results are produced.

"But will such an understanding really help my training progress?" is a question I am frequently asked.

The answer is "NO." No amount of theory will help your training progress – not, at least, UNLESS IT IS USED TO GOOD PURPOSE.

But, on the other hand, without a clear understanding of the theory involved, GOOD TRAINING PROGRESS IS IMPOSSIBLE.

Thus, in very simple terms, such knowledge is a prerequisite for good training progress – but does not guarantee such good results.

So much for the IMPORTANCE of the subject – now we will get down to the nitty-gritty, but I do want to point out in advance that anybody who fails to understand this article should quit weight-training immediately; because I am going to write it in such a way as to be understood by anyone.

Furthermore, we will simply be using the basic principles of the laws of physics which some people do not understand.

I find it necessary to write an article such as this; simply because it seems that almost nobody has ever made any serious attempt to apply the basic laws of physics to the field of exercise; instead, many people have blindly (if in many cases honestly) stumbled around in the dark in search of a source of illumination while holding the light switch in their hands all the time, and a few other people have produced a small candle in a large cave of ignorance and falsely proclaimed that it was the Sun.

And kindly don't start telling me how big some particular bodybuilder's arms are, while pointing to such arm size as proof of his great knowledge on the subject of exercise. The production of any given result (no matter how spectacular it may be) proves nothing beyond the simple fact that a particular method is capable of producing a given result, eventually.

And it certainly does not follow that some other method could not have produced the same result more quickly – or without requiring so much effort. I have never claimed that the Nautilus method and systems of training are the FINAL answer – and I never will make such claims, but do claim – and I can prove, and have proven to a lot of people – that the methods we are now using are at least ten times as productive of results as any previously-existed method of training.

So, at the very least, we must do something "better" – if perhaps not perfectly; in fact, and I have repeatedly tried to make this point clear in a number of previously published articles, the new machines have produced such an enormous increase in the production of results that I actually consider them a bit dangerous in some ways. What happens, for example, when a man gets so strong that his muscular strength exceeds the ability of his framework to support such strength, when he can squat with so much weight that it crushes his spine or breaks his leg bones?

Less than two weeks ago, a former Florida State Powerlifting champion visited our gym for the purpose of training on the new equipment – but then left without doing so. Why? Well, I can't honestly answer that question with any real assurance or accuracy, but I do have an opinion. I think he was totally unprepared for what he saw – mentally unable to accept it. I think it "blew his mind."

Because, while he was preparing to perform his first set of squats, one of our trainees took 15 pounds more than this recent champion's best lifetime squat weight, and then performed (12) twelve full repetitions with it very rapidly. FULL SQUATS – not half squats or parallel squats – all the way down, buttocks to heels.

This particular trainee is now working toward a goal of doing sets of fifty (50) repetitions in the full squat with 450 pounds – and I have made a bet that he will reach that goal. And if he does so, you can be very sure that he will be the first man in history who ever did.

But why such high reps? Simply because this particular trainee is just too strong to even attempt to handle the weights that he could perform with it if he did sets of a lower number of reps; he is trying to build strength and muscular size – not kill himself. But in order to build either strength or muscular size, you must force your muscles to work against ever-increasing loads – and eventually you may reach a point where your strength is too great for your supporting structure of bones.

So – when you do get that strong, which you will if you train right – you have two choices if you wish to continue to progress; you can either endanger your bones and tendon attachments, or you can use less weight and perform a much higher number of repetitions.

Most people do neither; instead they fall into a rut of using the same amount of weight for sets of a given number, never really forcing themselves. And invariably their progress comes to an immediate screeching halt, or slows to a snail's pace. Whereupon they look around in desperation for some "secret" to unlock the door to additional progress; having overlooked the plain fact that their "style of training" is really to blame.

The human muscular structure is capable of growing at an almost alarming rate, as has been clearly demonstrated in thousands of cases with beginning trainees – and THERE IS NO SLIGHTEST PHYSICAL REASON WHY SUCH A FAST RATE OF GROWTH CANNOT BE CONTINUED STEADILY RIGHT UP TO THE POINT OF INDIVIDUAL POTENTIAL.

But if that is true (and it is true), then why do most trainees experience such slow rates of growth after the usual initial spurt of fast growth that occurs in the case of most beginners?

Because, at the start of training "any training" was a new experience for their muscular structure, and growth was stimulated; but later they fall into a rut of doing the same things over and over again; no new demands for additional strength or size are being imposed, and progress will become much slower or stop altogether.

And what does this have to do with basic physics? Just EVERYTHING, that's all. While there is nothing even beginning to approach scientific agreement on the subject of just "why muscles react in this fashion" it is nevertheless self-evident truth that muscles do in fact react to exercise, or lack of it, by growing or by losing size and strength.

When a muscle is not exposed to frequent workloads that require it to use a high percentage of the existing level of strength, then the muscle very quickly loses both size and strength – apparently because the muscle "decides" that such size and/or strength is no longer required, and thus sees no reason for maintaining something which is of no benefit to the body as a whole.

Likewise, if a muscle is exposed to a workload that is beyond its momentarily existing level of strength – or a workload that forces it to work inside a certain (but unknown) percentile of reserve strength – then it will respond by growing larger and/or stronger.

All of the above should be perfectly clear to any trainee – and yet many thousands of trainees train in such a fashion that it is obvious that they really don't understand it at all. For maximum-possible progress, every set of every exercise must be carried to the point of utter failure – to a point where a full 100% effort producing nothing in a way of movement of the resistance or the body part being worked.

There are SOME – but really very few – exceptions to the above stated requirement for maximum possible effort; such maximum effort is not required if you are simply trying to reduce by burning off excess fatty tissue; in that case, maximum expenditure of energy is of greatest importance, and this can be done by performing large numbers of very light movements that never require anything even approaching a maximum effort. Also, some people require a bit of "warming up" prior to heavier exercise, and many people like to perform a few such light movements even though they don't really require them; but it should be clearly understood that such LESS THAN MAXIMUM efforts do ABSOLUTELY NOTHING in the way of building either strength or muscular size.

But, properly performed, even your light warmup sets can, and should, add to your progress. A paradox? No, simply common misunderstanding; light sets can be of value, if they are carried to the point of failure following a maximum effort. Thus they become "light" only in the sense that the weight being used is rather low.

So if you require or desire light warmup sets, then use them; but carry them to the point of utter failure; curl until you can't even start to bend your arms and the weight drops out of your exhausted fingers, or press until you can't even jerk the weight away from your chest.

"But," you might say, "if I do that, then I can't handle as much weight in the later, heavier sets; thus my poundages will drop, and my results will be less rather than better."

WRONG, wrong, wrong – just how wrong can you get? Your muscles don't know how much weight you are using; if the weight being used is enough to require a maximum output on the part of your muscles, then that is all that is required – whether this is two ounces or two tons is of no slightest importance. At least insofar as building muscular size and/or strength is concerned; building the strength of tendon attachments is another matter entirely, since the tendons are merely "cables" attaching the working muscles to the supporting bones, they are not apparently subject to much, if anything, in the way of growth, but the attachments can be injured if a top heavy load is imposed upon them. And the attachments can be strengthened if they are exposed to gradually increasing loads, in much the same manner that muscular strength is induced by exercise.

So what I am saying is this; make your warmup sets part of your productive workout; and this can only be done if such sets are carried to a point of maximum-possible effort leading to failure.

A clear understanding of, and a willingness to practice, this requirement for "maximum-possible effort" is basic for the production of good results in any sort of physical training designed to increase strength or size. If you are unable to understand that – or unwilling to practice such hard training then don't bother to read the rest of this article, because in that case you will be wasting your time.

But for those who wish to continue…

Individual muscle fibers are shaped a bit like a canoe, when they are relaxed, and when they are flexed (working); they reduce their overall length while increasing their width, becoming shorter and thicker.

For the purpose of this explanation, let us imagine a long line of canoes extending down a straight stretch of river; the nose of each canoe being fastened to the bank by its tail, and the last canoe in the long line is attached to a large raft which is floating freely in the stream, a raft that is prevented from floating away on the current only by the fact that it is hooked to the final canoe in the long line of canoes.

In effect, we have a "rope" made up of a line of 100 canoes. Each canoe is 10 feet long, so the rope of canoes is 1,000 feet long.

If you can picture that situation, then you have a fair idea of just how one individual "strand" of muscular fibers would appear under a powerful microscope while in a totally relaxed state.

Then, suddenly, one of the canoes "shrinks" – reduces its length by half, becomes only 5 feet long instead of 10 feet long. If the canoe that shrinks is one of those located at the exact midpoint of the rope, then the rope will not be affected above that midpoint – but the entire number of canoes below that midpoint will be affected; the overall length of the lower half of the rope will be reduced from an initial length of 500 feet to one of 495 feet, and the raft will be pulled upstream a distance of 5 feet.

Only one canoe can perform any actual "work;" the one that shrank. But the canoes below it will be moved, and may be exposed to a slight bit of accelerative force during that movement.

Now, it should be obvious that the raft could be pulled upstream a distance of 500 feet if all of the canoes were to shrink in half of their initial length; and it should also be obvious that such a "total movement" of the raft is impossible WITHOUT SUCH WORK ON THAT PART OF EVERY SINGLE CANOE.

A muscle works in much the same way; each individual fiber (canoe) works by reducing its length; and for total movement of the body part being moved by that muscle, ALL of the fibers must be working at the same time. BUT ONLY ALL OF THE FIBERS IN ONE STRAND OF MUSCLE.

If the load being moved (the raft in the above example) is quite light then maybe only a few such strands of muscular fiber are required to move it, and not one single fiber that is not required will be called into play. Individual muscle fibers work on the well-known "all or nothing" principle – they are totally incapable of "degrees of work;" they are either working as hard as possible, or not at all.

Thus, in order to involve ALL of the fibers in the entire muscle in the work, it is necessary to use a weight that is heavy enough to require such "all out" effort.

But it does not follow that even using such a heavy weight will actually cause all of the fibers to become involved. In fact, it is utterly impossible to use more than a fairly low percentage of the total fibers in a muscle, no matter how heavy the weight is, even if you used ten tons for a curl; or, at least, this is true if you are training with conventional types of equipment. I will now clearly explain "WHY" this is not only true, but obviously, self-evidently true – indisputably true.

Let us return to the example of the canoes…

If we had only one such "rope of canoes" and if a weight was added to the raft which made it possible to move the raft; in that case, to move the raft we would have to add another, a second, line of canoes to the first one, parallel with it, helping it. Assuming that two lines of canoes could then move the raft in spite of its now increased weight, then it is obvious that the raft would start moving upstream, and that it would complete its journey of 500 feet only when all of the canoes were contracted, in which case all of the canoes in both strings would be working together.

But if, before it had moved the full 500 feet, the raft was approached from behind by a power boat and was pushed the final 200 feet of its trip upstream, then the load would be removed from the canoes before it was even possible for all of them to be involved in the work; and that is exactly what happens in all forms of conventional exercise.

Individual muscle fibers CANNOT flex, unless the involved body part is in the proper position – and they WILL NOT flex unless they are needed to meet the demands imposed by an existing load. And all of this is obvious.

If all of the individual muscle fibers were flexed at the same time, then the involved body part would have to be in a fully contracted position; in no other position is it even possible for the fibers to flex.

If the load is removed or decreased, prior to the time that the moving body part has reached a position of full contraction, then no requirement for the involvement of the total number of available muscle fibers is being imposed.

Yet, with one or two minor exceptions, no conventional form of exercise provides any resistance at this point in the exercise; at the very time when greatest resistance is required, and when any resistance is of greatest possible value, there is literally NO resistance.

Take the squat, for example. As should be obvious, all of the muscles fibers of the thigh simply cannot become involved in the exercise unless the leg is moved into a fully flexed position (straight, in this case); yet in that position there is literally NO resistance. Having moved into that position you can stand there with little or no effort, and literally none insofar as the thigh muscles are concerned, apart from the tiny amount of effort required for balance.

So there you stand, having moved with great difficulty into a position where it is finally possible to involve all of the muscle fibers of the frontal thigh muscles – and with nothing in the way of resistance available to work these muscles.

Another example? The curl; at the top, when it has finally become possible to use all of the fibers, the resistance is removed – just when you need it, you don't have it.

Other examples: The press, the bench press, the leg press, even most forms of chinning; you name it, it probably fits.

Exceptions? Very few. None of any great significance; the thigh situps on a decline board, certain forms of wrist curling, the so-called "triceps-kickout," and a few others.

Rowing motions, pulldowns on a conventional lat machine, and most other pulley exercises are not exceptions, although at first glance they might appear to be; because, in these cases, even though the resistance is not removed in the fully flexed position, the exercises involve working the interconnected and far weaker muscles of the arms – and you fail at a point where the arms are exhausted, long before the larger, stronger muscles of the torso reach a point of worthwhile stimulation.

By putting yourself into some rather weird and usually very uncomfortable positions, you can work SOME of the muscles fairly well in their fully flexed positions while using conventional types of training equipment, but again, the laws of physics prevent you from reaching anything even approaching a really worthwhile type of movement.

Why? Because you are trying to work it with reciprocal resistance; and thus, in all cases with conventional equipment, you are limited to a MAXIMUM of something less than 90 degrees of worthwhile movement – while some muscle structures require a range of movement against resistance of over 240 degrees, and some muscles require a compound range of movement of nearly a full 360 degrees.

If you have understood the above, then it should be obvious that what is required is a type of resistance that provides the following characteristics… (1) full range movement against resistance, (2) rotary resistance, (3) omni-directional resistance, (4) variable resistance, a weight that grows heavier as the movement progresses from a position of full extension to one of full contraction, (5) balanced resistance, a weight that is exactly right in every possible position; not so heavy that it makes movement impossible, but heavy enough to require the working of all the individual muscle fibers in the muscle being exercised.

Conventional forms of exercise provide NONE of those characteristics in most cases, and all of them in no cases.

Nautilus equipment provides all of them in most cases, and most of them in all cases.

How? – Again we return to basic physics, and to the point of "distance, resistance, and speed." Since we can't actually cause the weight to grow heavier as the movement is in progress, not at least without having somebody standing there adding plates as you go up and removing them as you go down, and since we can't force you to work faster, then we are left with only one remaining possible choice; you must be forced to move the weight a greater distance – thus we use the new Nautilus spiral pulleys.

At the start of a curl, for example, the radius of the pulley might be 6 inches – but as you start to bend (curl) your arms, and thus cause the pulley to rotate, the radius of the pulley changes, grows larger, and the weight is thus being moved a greater distance, and more power is required to move it this greater distance.

At the end of the curl, the radius might then be 12 inches; twice as great as it was at the start, and thus the torque (the effective resistance) is twice as great as it was at the start.

It's just that simple; that is to say, about as simple as a jet aircraft, which is quite simple in theory if not in fact.

What do I know about the physics of flight? More than most, less than some – after 31 years of active flying, I still hold a valid airline captain's license and have logged 17,300 hours in flight, most of it in international transport category aircraft.

Any other background in physics? Well, for fourteen years I have been a motion picture producer, with more than 300 films to my credit; my most recent released film being a CBS Network, one-hour, color special first telecast on Friday, August 28, 1970, a film called "Free to Live: Operation Elephant."

And what does producing movies have to do with physics – or with a knowledge of physical training? In most cases, perhaps very little, or nothing; but in my case quite a lot. To begin with, such activities as producing films and operating an international airline provided me with the funds that made it possible for me to spend a rather sizeable slice of my time over a period of thirty years, in a detailed study of the subject of exercise. Second, my filming activities have been of such a nature that I have been forced, by necessity, to design and build quite a lot of required equipment, such as things as utterly new types of lenses for motion picture cameras, perfectly stable floating platforms that make it possible to film under ANY conditions without a trace of vibration in the resulting films, equipment for chasing, capturing and moving whole herds of elephants, and a number of other things.

Twelve or thirteen years ago, a large national magazine ran a feature article on me in which they made some rather strong statements (all favorable, if perhaps not quite true); the title of that article was, "His job is DOING THE IMPOSSIBLE." An overstatement, of course, but remember, they said it, I didn't.

But, back to the subject of importance; my personal background has nothing at all to do with the validity of my theories and/or the value of the machines – either the machines work, or they don't, and who made them is of no concern.

But I will add that eight members of my family are medical doctors, father, mother, brother, sister, paternal grandfather, uncle, cousin, and brother-in-law, and that my youngest daughter has just been accepted by a major Florida university for the start of her pre-med work in preparation for her M.D. degree, and that my eldest son is working towards a doctorate in math in the same university; which university, not so incidentally, has a large computer, without which computer, any reasonably smart genius could probably work out the exactly required shape of the spiral pulleys that we use in the Nautilus machines in only eight or ten thousand years – if he worked around the clock without wasting time on such foolishness as eating and sleeping.

A twenty-eight year old high school teacher in Chicago who is working on his master's degree, called me yesterday and we talked by long distance for well over an hour; during that conversation he told me that he understood the workings of my machines perfectly and that, frankly, when he first read my article in Ironman it literally "made him sick," because, he said, he had known for years that "something" was wrong with conventional forms of exercise, but that he had been unable to put his finger on the exact problem – until he read my articles; whereupon, he realized just how simple the problem (if perhaps not its solution) really is. He now plans, he told me, to write the thesis for his master's degree on the working of my machines, and on the principles upon which they area based. If this comes to pass (as it should) Mr. Rader might later publish it in Ironman.

In the meantime, for those who still want more information, we have prepared and are offering Bulletin No. 1, a much longer, straight to the point outline of the new principles, and a number of what I consider very valuable tips for incorporating the use of these new principles to weight training without the requirement of any new pieces of equipment.

You cannot, of course, win a horse race on a camel; and you cannot produce the same results that we are producing with the Nautilus equipment without using that equipment, but you can markedly improve the results you are getting from conventional training by using the same principles, where, and as, possible.

Nor will you produce spectacular results even with the new equipment if you fail to use it properly; these are not, after all, miracle machines; they are simply tools (if perhaps enormously improved tools), and as such they are subject to misuse like any other tool.

So, if you expect miracles, or if you are looking for an “easy” method of training, then look elsewhere, because you won’t find such things here. Very productive as the new machines certainly are, and fast, they just as certainly are not “easy.”