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The Nervous System in Sports

A clear understanding of a few simple facts about the nervous system is essential to an understanding of human performance. But do not be put off through a fear of medical terms or complex theory. The following is written in plan language… and the information presented is important to anybody involved in sports of any kind.

I want to make at least two points perfectly clear. First, it is impossible to involve the entire mass of any skeletal muscle in a normal contraction. This simply means that a person never uses more than a rather small percentage of any muscle at any time. Even in a maximum possible live or die attempt, only part of any muscle is being used… while the balance of the muscle, the largest part, is resting.

But if that is true, it might be asked, then what purpose does the extra unusable mass of muscle serve? The extra muscular mass serves a very important purpose, it provides muscular endurance. And it is usable, but not in concert with the rest of the muscle.

If all of the fibers in a muscle are fired simultaneously, the resulting force would be so great that the muscle would probably be torn loose from the bones. Or the bones themselves might be broken. Some people surviving accidental electrocution suffer broken bones as a direct result of the violent muscular contractions that are produced by a strong electrical shock; and electrocution almost always produces torn muscles or connective tissues.

The following figures and percentages are not intended to represent an exact situation; instead, they are merely used as a necessary part of an example, intended to make the previously mentioned point clear.

If, for example, a particular muscle contains a total of 100 fibers, a person might be able to contract only 30 of those fibers at any particular moment. Thus, even when he is working as hard as possible, he would be using only 30 percent of the available fibers… while 70 percent of the fibers were resting.

If a person could use100 percent of a muscle simultaneously, and if he could withstand the resulting forces, then he would be utterly helpless after one very brief effort… because all of the fibers would be exhausted simultaneously, leaving absolutely nothing in reserve for a second effort.

Individual muscle fibers contract as hard as possible, all or nothing. So, in a maximum effort, some of the fibers are working as hard as possible, and some are doing nothing.

When a person reaches a point of momentary muscular failure, he may think that his strength has been totally exhausted; but in fact, a very high percentage of strength is still available. It simply is not enough to produce movement against the imposed resistance.

For example, if a person performs one repetition of a maximum bench press with 300 pounds, then it will be impossible to perform a second repetition immediately. But not because his momentary level of strength has suddenly been reduced to zero. In fact, his strength will be almost as high as it was at the start; but not quite as high to lift the weight a second time.

Performing one maximum repetition reduces a person's beginning strength level by approximately 4 percent… leaving him with about 96 percent of his starting strength left to perform a truly maximum lift, and anything less will not do it. So the person is forced to stop, even though 96 percent of his strength is still available.

But, a person might say, if I use only 30 percent of a muscle, even in a maximum lift, I should be able to perform several repetitions with a maximum weight; the first repetition would exhaust 30 percent of the muscle, the second repetition would exhaust a different 30 percent of the muscle, the third repetition would exhaust a final 30 percent of the muscle, and I would still have 10 percent of the muscle remaining unused.

This would be true… if the same fibers worked throughout the entire repetition; but they do not. The contraction of an individual muscle fiber is very brief; and in most situations, a fiber cannot continue to produce force throughout an entire movement. So individual fibers contract as hard a possible, but very briefly… and if force is still needed, then another fiber takes over and continues to work. If a person will observe a muscle during hard work, he can actually see the twitching that occurs during strong and continued muscular contraction.

So, if it is true that a muscle uses only 30 percent of its fibers during a maximum effort, then it is obvious that something less than 30 percent of the fibers are available immediately for a second attempt.

A fresh, rested muscle is capable of contracting 100 percent of its fibers simultaneously… but the nervous system is not. Muscular contraction is triggered by an electrical impulse from the nervous system, and there are not enough nerves available to stimulate all of the fibers at the same time.

So, even when all of the nerves are working simultaneously, there are only enough nerves to trigger 30 percent of the total number of muscle fibers. Once triggered, a second repetition immediately following will be even weaker for two reasons. First, because then the individual will not have enough fresh fibers available to take advantage of the stimulation that is being provided… and, secondly, because the electrical stimulation from the nerves will also be weaker.

This leads to my second point. If an average man can contract only 30 percent of a particular muscle, it does not follow that all men are thus equal, some individuals can contract as much a 40 percent of the same muscle, and a few rare individuals can contract 50 percent of the muscle.

This means, in practical terms, that some men are far stronger than other men, all else being equal.

But it also means that these stronger-than-average men have less than an average amount of muscular endurance – not cardiovascular endurance, which has nothing to do with the matter, but muscular endurance.

If an average man, a 30 percenter, can bench press 300 pounds once, then he can perform ten repetitions with 250 pounds, and will fail while attempting an eleventh repetition.

But a smaller man with less muscular bulk might also bench press 300 pounds once… if his nervous system was better than average, if, for example, he was a 40 percenter. Yet this same man would not be able to perform 10 repetitions with 250 pounds; instead, he might fail after only 7 repetitions. His maximum strength would be equal to that of the larger man, but his muscular endurance would be less.

In fact, the bench press is actually not a very good lift to base such a comparison, simply because bench pressing is a test of skill as well as strength. But if a pure test of strength is used, then the results would be close to the percentages shown previously.

Such differences are genetically determined; which means, in plain language, that a person can do absolutely nothing to improve his nervous system. Most athletes are blessed with better than average nervous systems, which is largely responsible for the fact that they are athletes.

Almost anybody can increase his muscular bulk, and doing so will make him stronger; because 30 percent of a large muscle will produce more force than 30 percent of a small muscle. But it does not follow that all men can increase their strength equally, although the percentage of strength increase may be equal.

Two men might be identical twins, with all visible factors including muscular bulk being exactly equal… the only difference being the fact that one man was average, a 30 percenter, while the other man was above average, a 40 percenter. In such a case, the 40 percenter would be markedly stronger, for no apparent reason; he would be stronger because he was able to use a large part of his total muscular bulk during a maximum effort.

His muscle would in no way be superior to the muscle of the other man. His greater strength would be a result of a better than average nervous system.

The weaker man might be able to bench press 150 pounds, while the stronger man could lift 200 pounds in the same manner; and then, later, as a result of strength training, the weaker man might double his strength, thus making it possible for him to bench press 300 pounds… while the stronger man would increase his strength by an equal percentage, but by a greater amount, and would then be able to bench press 400 pounds.

So the man with the weaker nervous system actually has more to gain from strength training than the average man does. This is simple once the related facts are clearly understood; but in many cases, this leads to confusion rather than understanding.

The result in many cases is that the very individuals who stand to gain the most from strength training are the ones who avoid it entirely.

A man with only an average amount of muscular bulk, but a superior nervous system may well be stronger than another individual with much muscular bulk but with only an average nervous system. In this case it becomes easy to make the mistake of assuming that the extra muscular bulk is useless, or even that it somehow makes the man weaker.

Additional confusion is added by another common mistake; skill is often mistaken for strength… so a weaker man might be able to bench press more than a stronger man, if he is more skillful in the performance of that particular lift.

So if we have one man with great skill and a superior nervous system, then he might bench press far more weight than a much larger man with an average nervous system who has very little skill at bench pressing. In this case, it will appear that the greater muscular bulk is of no value, but such an appearance is utterly false.

A muscle is strong in almost direct proportion to its cross-sectional area; so the larger the muscle, the greater the strength. But a third factor now enters the picture to confuse the issue even more. Overall size is often mistaken for muscular size… a large arm may contain a high percentage of fat, and the actual muscular size may be only average. Fat will make a person larger, but fat is not muscle… fat does not contract, fat does not produce force, fat merely adds the burden of non-working weight.

And a fourth factor adds even more confusion. Bodily leverage is a genetic factor that can easily add as much as 50 percent to the usable strength of an individual. One man, with short arms, may lift a barbell a distance of only 14 inches in a bench press… while another man, with longer arms, may lift the barbell 21 inches in a bench press, 50 percent more than the other man.

Outstanding athletes usually have very good bodily leverage for a particular activity, a superior nervous system and great skill… but they almost never have more than average muscular bulk. Convincing such a man that he stands to gain by increasing his muscular strength, is frequently an impossible task; after all, he feels he is already superior… so of what use to him is more muscular bulk?

He will probably be superior to many other men with far greater muscular bulk… and since he will almost always fail to understand the actual factors that make him superior, he will probably make the mistake of assuming that increased muscular bulk might actually reduce his performance.

And it is a common mistake, almost a universal mistake… but a terrible mistake; a mistake that literally prevents the best athletes from reaching their real potential. The very men who stand to gain the most from strength training are usually afraid to try it. Fifty years from now, all athletes in all sports will use strength training as one of the most important parts of their training… at which time they probably still will not understand why it is of such great importance; but they will, at least, believe in strength training… and they will have lost their fear of strength training.

In the meantime, millions of athletes and thousands of coaches are almost desperately looking for some sort of an edge, literally anything to give them an advantage; while continuing to ignore the one remaining edge, the one factor that is seldom exploited, strength training.

Strength training will not make a superman out of an average man, and nothing else will either. But it will improve the performance of any athlete in any sport.

And it will not make him slower… in fact, it will make him faster.

And it will not reduce his flexibility… in fact, it will increase his flexibility.

And while it will do absolutely nothing to help his skill… it will do nothing to hurt it either.

And it will not make him immune to injury… but it will reduce his chances of injury.

The muscles are the engine of the body; the muscles produce force… the muscles produce movement… the muscles provide energy. Without muscles a person would be utterly helpless, unable to move; yet, here we are in the last quarter century of the twentieth century and most coaches and athletes are still literally afraid of their muscles.

When (and if) the next great step forward comes in sports, it will be a direct result of proper strength training but it will occur only when the present attitude of fear is gone, only when the old myths and superstitions have died, if they ever do.

In the meantime, in many ways, the situation is getting worse instead of better… primarily because a whole new set of myths and superstitions are currently being added to the old ones; many of these false beliefs are concerned with the human nervous system and its relationship to functional ability.

The nervous system itself is not capable of improvement… but a person can, and he certainly should, improve his ability to make use of the system that he does have. The development of skill is nothing more or less than an improvement in the use of the nervous system; but the potential for improving the use of the nervous system does not stop with the development of skill.

Instinct plays a far more important role in human activities than most people realize, or like to admit, even when they do suspect its importance… and instinct, even though it produces automatic reactions more or less beyond our control, can still be used to great advantage. The stretch reflex is a good example of such a usable instinct.

Muscles are arranged in pairs… one set of muscles on one side of a joint for the purpose of bending at that joint, and another set of muscles on the opposite side of the same joint for the purpose of straightening the arm at the joint of the elbow.

The muscles in front of the elbow joint, primarily the biceps, bend the arm… the muscles in the rear of the elbow, the triceps, straighten the arm. Similar situations exist on both sides of all human joints, although many are far more complex than the muscles involved in movement around the elbow joint.

Depending upon the desired direction of movement at the moment, these opposite working sets of muscles are called either agonist muscles or antagonist muscles… an agonist muscle produces movement by contraction… while an antagonist muscle limits or stops movement by refusing to permit itself to be stretched.

In order for movement to occur, an agonist muscle must reduce its length, contract with a pulling force that produces movement… but simultaneously, the antagonist muscle must permit movement, by allowing its length to be increased. Thus, during all movements, while one set of muscles is getting shorter, another set of muscles must be getting longer.

It is obvious, then, that a person must relax the muscles on the one side of a joint in order to produce movement by contracting the muscles on the other side of the same joint; and in practice, he does this automatically, instinctively, and probably without even being aware that he is doing so.

In any activity involving sudden movement, a person must relax the antagonist muscles instinctively because it occurs so rapidly that there simply is not enough time for thought. So the nervous system provides this service on an instinctive level, as it must.

But… even though this occurs instinctively and automatically, it does not follow that we must remain unaware of this instinct; nor does it follow that we cannot control this instinct to some degree, thus using it for our own purposes.

In fact, very valuable use of the stretch reflex can be made in proper strength training… and should be, but with knowledge and an understanding of the involved factor, so the use of this instinct will produce good results instead of injuries. Using this instinct properly will lead to an increase in the results produced by strength training… using it improperly will almost certainly produce injury.

The stretch reflex is one of several protective instincts of the body. It is intended to keep a person from hurting himself. When sudden movements occur anywhere in the body, the antagonist muscles almost instantly come into play to stop that movement… because… if rapid movement is allowed to continue to the end of the possible range of movement, then damage will probably be done to either the muscular structures or the joints.

A person's arm can straighten only so far, and if it reaches that limit while moving at a high rate of speed then something will be damaged; so the stretch reflex comes into play, sends a signal through the nervous system to trigger the action of the antagonist muscles, and either slows or stops the movement, thus reducing the chance of injury.

All of this is well and good… but it does not stop here. The same stretch reflex is used by our bodies for an entirely different purpose… as an aid to functional ability, and as a means of increasing our usable strength, making it possible for us to jump higher, hit harder, and throw a greater distance.

When a person punches with his fists, he draws his arm back first… but not for the reason that he probably thinks; he does not draw his fist immediately prior to a punch in order to give the fist a greater range of movement. Instead, he does so in order to bring the stretch reflex into play… the result being that he literally has two separate sets of muscle fibers working for him at the same time when he punches. He has one set of muscle fibers that are working normally, under his control, and another set of fibers that are working instinctively as a result of his stretch reflex.

When a person suddenly pulls back his arm before a punch, he automatically triggers the stretch reflex, which then begins the antagonistic muscles into play to stop the sudden movement to the rear. Then, while these fibers are working to slow or stop the rearward movement, he reverses the action and contracts the punching muscles. These muscles are already working as a result of the stretch reflex. The result is that much higher than normal percentages of the muscles become involved in the punch, the punch travels faster, and he hits harder.

Exactly the same thing occurs when a person dips just before jumping or when he backswings with a baseball bat. A similar utilization of pre-stretch inadvertently occurs in golf, tennis, bowling, and most other active sports.

If a person stopped a barbell at the bottom and then started from a stationary position, he might be able to bench press 300 pounds… but if, instead, he allowed the barbell to drop slightly just before starting to press, then he might be able to bench press 350 pounds, or more.

And… I certainly am not suggesting that a person bounce the barbell off his chest; bouncing has absolutely nothing to do with it. The increased usable strength is a result of the stretch reflex. The same thing can easily be demonstrated even when the barbell never touches the chest. For example, take a weight that is slightly below maximum for one repetition, stop the movement with the barbell about an inch above the chest, and then start from a dead stop… then, during the second repetition, stop the barbell again when it is an inch above the chest; but this time do not start from that position… instead, let the barbell drop a distance of only half an inch, still do not touch the chest, and instantly start to press. A person will find that the second repetition is actually easier than the first one, even though he will obviously be weaker by that point in the exercise. The second repetition will be easier because of the help he is getting as a result of the stretch reflex.

So far, so good… but do not make the dangerous mistake of going too far in this direction. Do not wrongly assume that a big drop will be better than a small drop; it will not be. A very short, very brief drop is all that is required, and a longer drop may well produce an opposite result, thus making a person weaker. And a longer drop will certainly produce a dangerous situation that can easily cause injury.

Triggering of the stretch reflex occurs in microseconds, literally in a tiny fraction of a second. It takes very little to set this instinct to work; more is certainly not better in this instance.

On the contrary, prolonged stretching will actually reduce a person's momentary strength.

And, of equal importance, a longer drop of the weight will build up a high level of momentum in the barbell; force will be trying to move in the opposite direction… an additional force that a person will be required to overcome in order to press the weight. Even the slight, short drop of a properly executed repetition will add some force in the wrong direction, but the extra reflex will more than compensate.

At the moment, an enormous amount of controversy exists on the subject of speed of movement during strength training exercises; so, I feel that it is of great importance that what I am saying here is not misunderstood. I am not suggesting sudden movement. I am not recommending a so-called explosive style of training; on the contrary, the facts are perfectly clear on this point at least… sudden or jerky movements should be avoided during strength training exercises. They have absolutely nothing to offer except the danger of injury.

The movement that occurs during an explosive lift literally occurs so fast that the muscles are unable to keep up… the result being that the involved muscles are exposed to a dangerous jerk at the start of the movement, and then are not involved at all during most of the movement.

The practice of fast lifts will build little or absolutely nothing in the way of actual strength in the muscles, instead, a person will learn the skill required to throw a barbell; that is right, throw a barbell… because he certainly is not lifting it.

For a weight lifter such skills are a necessary thing… but they are utterly useless for any other athlete; and developing the skill to throw a barbell is unavoidably dangerous, a danger to which active athletes should never be exposed.

Unfortunately, many of the current strength coaches come from the old school, being former weight lifters themselves. As weight lifters, they had to train in that manner in order to develop the skills required for weight lifting; so it naturally follows that they pass on this style of training to other athletes, football players in particular.

The result is that many thousands of football players and other athletes are now being forced to take part in a style of training that is of absolutely no value for the purpose of developing actual muscular strength… and far worse, a style of training that is extremely dangerous. The so-called power clean is one common example of a lift that is of no value to anybody except a weight lifter, and is a very dangerous lift to practice.

So I am against weight lifting, right? Wrong. I have lifted weights for more than thirty-five years; for a long time in an explosive fashion, until I learned better… the hard way.

I am not against hitting and blocking either for a football player… because this is absolutely the only way that a football player will ever learn to hit and block. But it would be outright insanity to suggest that a swimmer or a basketball player should also practice hitting and blocking.

And it is equally insane to suggest that football players should engage in activities that are required for a weight lifter… but are of no value to a football player. Yet this is exactly what is happening in literally thousands of cases, simply from lack of knowledge.

The barbell can be, and if properly used will be, a valuable tool for a football player, or almost any other athlete in any sport, but the barbell should be used for the purpose of increasing strength, not for the dangerous and useless purpose of developing skill at throwing a barbell.

During the course of the last three years, I have been both directly and indirectly involved in an activity that I have never before mentioned in print, even though, during these same three years I have published more than two dozen articles on strength training in several periodicals. I have avoided any mention of this activity for what I consider to be a very good reason… because I was afraid it would be misunderstood, and might lead to bad result rather than good results.

But now I will take what I consider to be the calculated risk of mentioning this subject in print… hoping that it will be understood and applied in context, but rather expecting that it will not be.

In the state of Florida, where I live, weight lifting is a high school sport. But, like all other sports, it is not practiced at every high school in the state; thus, until three years ago, weightlifting was not one of the sports practiced or engaged in by the DeLand High School. But for three years, it has been.

And… for three years, starting from scratch with no previous training or experience, the weight lifting team of the DeLand School has won every single meet it has entered. As of this moment, their record is 34 wins, no ties, and no defeats, including the state championship for each of the last three years.

The DeLand weight lifters train with barbells and with Nautilus equipment and a large and important part of their training consists of negative-only exercises, where the weight is lowered slowly, but is never lifted.

The skill required to lift a barbell explosively, to throw a barbell, is developed in the only way it can be… by throwing barbells; but the strength required to produce a truly outstanding weight lifter is developed in an entirely different manner, also the only way it can be, by performing strength exercises with smooth, slow movement, and by concentrating on the negative parts of the movements.

My personal involvement with the DeLand High School weight lifting team has consisted of providing the required training equipment, including most of the barbells even though I do not manufacture or sell barbells. It has also consisted of a very close relationship with the team's coach, Bill Bradford. Coach Bradford and I have worked closely together on a number of projects over a period of six years, including the long-range experiments that we conducted with a negative-only type of training.

We do not claim to know all the answers… but we do at least know what works best; now we are trying to find out exactly why certain things work best… hoping that such knowledge can then be put to use in a practical manner that will produce even better results.

And we also know some things that do not work at all, or very poorly… things that are dangerous, things that should be avoided. Heading the list of useless, dangerous things in the field of strength training is so-called explosive style of training, lifts such as the power clean, clean and jerk, and snatch.

We also know that even brief but hard training is actually far more than a possibility… in fact, it is an outright requirement for good results from strength training. During the West Point study, for example, we produced an average increase in neck strength of over 92 percent in a group of 18 football players in a period of only six weeks, as a result of only 12 workouts of approximately 8 minutes each.

Two brief weekly workouts, for a period of only six weeks… a training time of approximately 90 minutes, produced approximately a 1 percent increase in neck strength from each minute of training.

Fine and good, but perhaps even more training would have produced a better result. But, in fact, it appears that more training will actually reduce the production of results. Two other groups of West Point cadets trained for a shorter period of time, only four weeks and without supervision; one group trained twice weekly and increased their strength about 42 percent… while the other group trained three times weekly and increased only about 39 percent. So, on the basis of this study, it appears that three weekly workouts actually produce less results than two weekly workouts… and if this is true, then just what is the point of the extra weekly workout?

We intend to find out, in the only way possible, by conducting a long-range research program with a large number of subjects. But research alone is not enough. It must be carefully supervised research. Every single repetition of every exercise in every workout must be performed and recorded under close supervision. If not, then we can never be quite certain just what actually was done, and what was not done.

And it must be done right out in the open, where anybody can watch and the pre-experiment and the post-experiment testing must be done by outside experts, by people who are in no way involved in the experiment except for testing purposes. And there must be non-trained control groups who are also tested, and all testing must be done on a blind basis where the testers do not know whether a subject is a member of an experiment group or a control group.

So research can be, and should be, a very valuable course of valid and useful information, but only when it is conducted properly… which, in the real world, it seldom is.

It seldom is simply because most people who undertake research do not have the financial resources, the time, or the facilities required to do it properly. And, secondly, properly conducted research becomes very boring in short order, so it also requires a staff that is highly motivated, people who will devote the time and close attention that are absolutely essential to meaningful results.

Handing a project over to a graduate student and turning your back will not hack it; but in practice, this is what usually happens. Try coaching a football team in the same manner and see how long a coach keeps his job.

Up to this point, my company, Nautilus Sports/Medical Industries, has been a non-profit organization… simply because every cent that might have been profit has gone directly into research and development, in efforts to improve both the tools available for proper strength training and the use of these tools.

This situation will continue for at least several more years until we reach a point where it is literally impossible to devote the additional resources to meaningful research.

In the last six years alone we have introduced a number of valuable innovations into strength training… 1) full-range exercise… 2) rotary-form exercise… 3) stretching… 4) pre-stretching… 5) direct resistance… 6) variable resistance… 7) balanced resistance… 8) omnidirectional resistance… 9) resistance in a position of muscular contraction… 10) negative-only exercise… 11) negative-accentuated exercise… 12) hyper-exercise… 13) infimetric exercise… 14) brief but hard exercise… and a number of other important factors. Every one of these factors is a direct result of our long-range and continuing research programs; and the value of all of these factors has been proven and proven again by careful research.

The type of training that we are now recommending may not be the ultimate; improvements are almost certain to come in the future… but it is, at least, so far ahead of whatever type is in second place that no meaningful comparison is even possible.

And it should be clearly understood that the style of training we are recommending is usable with almost any type of equipment… with barbells, with conventional exercise machines, or with Nautilus equipment.

Better result will be produced with Nautilus equipment for the simple reason that only Nautilus equipment provides full-range exercise; but good results can be produced with almost any type of equipment if it is used properly… which it seldom is.

Strength training exercises, practiced in an explosive fashion, will not give athletes explosive power to use on a football field or a basketball court… instead, it will eventually give a high percentage of injuries to their muscles and joints.

Building strength is one thing. Demonstrating strength is an entirely different matter. Do not confuse the two.