DENLINGER'S DISCOVERY APPLIES ENGINEERING BASICS to SPINAL BIOMECHANICS to IDENTIFY VOLUNTARY "SPINAL SPRING MUSCLES"™ and REVEAL FOUR AREAS of FUNCTIONAL IMPROVEMENT

ORIGINAL PAPER

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More information is available at www.NeckBackFootPain.com

The Voluntary (Gray 249)[1] Spinal Spring Muscles™ discussed in this paper are known medically as: in the cervical region the longus colli; in the thoracic region the spinalis thoracis and the semispinalis thoracis; and in the lumbar region the "erector spinae" along with its extensions longissimus thoracis and iliocostalis lumborum (Gray 462-469). These voluntary muscles, which can be used to cause the spine to function as a spring or mechanical shock absorber, play a very important role in spinal stability. The effects and control thereof will be discussed in detail in this article.

The meliorations emanating from correct application of the Spring Muscles™ will first be listed and then described in detail:

1.) Spring action
2.) Increased load carrying capability
3.) Load on discs distributed rather than concentrated making for possible improvements to or preventions of herniated discs
4.) Reduction of load on redundant (i.e., backup) ligament system

See Appendix for additional explanation of engineering basics which will be applied in this article.

From a student of engineering's viewpoint the human spine can appear to be a very complex structure. To get an idea of just how complex, here is a description of the spine as a student of engineering may express it:

SOLID BLOCKS (VERTEBRA BONES) STACKED ALTERNATELY WITH RUBBER BLOCKS (INTERVERTEBRAL DISCS) IN A CURVED (THE THREE MOVABLE CURVES OF THE SPINE), DEFLECTABLE (I.E., THE SHAPE CAN BE MADE MORE CURVED OR LESS CURVED, BOTH ANTERIOR-POSTERIOR AND LATERALLY AS WELL AS ROTATED), COMPRESSIBLE AXIALLY LOADED COLUMN (I.E., THE CURVED COLUMN CARRYS LOADS IN COMPRESSION [RATHER THAN IN TENSION] ALONG THE Y AXIS ABOUT WHICH THE COLUMN IS SHAPED) WITH VARIABLE STRENGTH (CONTROLLED BY THE OPERATOR) EXTENSION SPRING MOTOR (I.E., VOLUNTARY MUSCLES) WHICH ARE USED TO RESIST THE DEFORMATION OF THE COLUMN AND THEN RETURN THE COLUMN TO ITS ORIGINAL SHAPE WITH A BACKUP SYSTEM (I.E., LIGAMENTS) TO MAINTAIN THE RELATIONSHIP OF THE PARTS OF THE COLUMN (I.E., THE SOLID BLOCKS/VERTEBRA AND RUBBER BLOCKS/DISCS) IN CASE THE EXTENSION SPRING MOTOR(S) (I.E., THE VOLUNTARY MUSCLES) SHOULD BE NON-OPERATIONAL SUCH AS WHEN DOWN FOR ROUTINE REPAIRS (I.E., RECUMBANT, RESTING OR SLEEPING) OR WHEN DAMAGED.

When dealing with a structure as complex as the human spine, is it any wonder that various functions of its structure can be difficult to decipher?

The test body referred to, unless otherwise indicated, is that of Mr. Denlinger.

INITIAL PARAMETERS

Prior to continuing it is necessary to come to the agreement that the human body, just like buildings, airplanes, moon rockets, motor cars and bicycles, is subject to the basic physical laws set down by Newton and other major scientific researchers. For example, a weight supported against gravity on a one square inch surface will cause more stress to the supporting surface than the same weight supported on a ten square foot surface. If this cannot be agreed upon, it would not be worthwhile to continue reading this paper.

SPRING ACTION

Wahl defines a mechanical spring as: "...an elastic body whose primary function is to deflect or distort under load (or to absorb energy) and which recovers its original shape when released after being distorted." (3)

In the cervical region the longus colli fits the function of the thoracic Spring Muscle™ and can be called the cervical Spring Muscle™. Partial contraction of the cervical Spring Muscles™ causes the cervical spine to be held nearly straight (minimally curved) and to be shaped so as to be capable of deflection or distortion into a greater curve in the process of absorbing the energy of a sudden vertically downward load or shock. The cervical Spring Muscles™ can then return the spine to the original shape to be prepared for another sudden vertical downward load. This distortion and return to original shape fits the description of a mechanical spring. Contracting the cervical Spring Muscles™ reduced the angle of the vertebra surfaces by 16 degrees total in the following locations: between C2 and C3: 3 degrees, between C3 and C4: 8 degrees, between C4 and C5: 1 degree, between C5 and C6: 4 degrees, between C6 and C7:

0 degrees (has disc degeneration) as measured on a x-ray of the cervical spine of the test body.

As with the cervical, partial contraction of the thoracic Spring Muscles™ causes the thoracic spine to be held nearly straight (minimally curved) and to be shaped so as to be capable of deflection or distortion into a greater curve in the process of absorbing the energy of a sudden vertically downward load or shock. The thoracic Spring Muscles™ can then return the spine to the original shape to be prepared for another sudden vertical downward load. This distortion and return to original shape also fits the description of a mechanical spring. Due to the interference of the ribs, it was not possible to measure the angle of vertebra surfaces on x-rays of the throacic spine.

When first searched for, no Spring Muscle™ similar to the cervical and thoracic was found in the lumbar region. Upon further investigation it was found that the lumbar Spring Muscles™ operate on a different engineering principle which is similar to, but definitely not the same as, that of a suspension bridge.

A suspension bridge, like a beam, spans the distance between two points to allow unentruded space to exist below the span. In Drawing No. 1 this span would be the distance between points C and D. The member (in engineering, a member can be a column, a beam, a cable, a post, a truss or any similar part of a structure) between C and D is supported by the vertical cables which connect it to the curved cable between points A and B. The cables are in tension; that is, they resist a pull on their ends similar to muscles. The member between points C and D hangs, or is suspended, from the cables, thus we have the term of suspension bridge (Pugsley; Steinman).

Here is where things become a bit tricky. To our knowledge, there is no common piece of mechanical construction in existance contructed similar to the human spine nor has a treatise been written on same.

So, you are probably wondering how this relates to the lumbar spine. As far as we know, this is original work. The first step is to rotate the bridge 90 degrees so the roadway is vertical and curve the girder/roadway between points C and D so the concave side of the curve is toward the members carrying the tensile forces. We also change the member between A and B from a beam/girder to a column which primarily carries a vertical load (see Drawing No. 2). The vertical column is the lumbar spine and the tensile members are the lumbar Spring Muscles™. The vertical load, per the Euler formula (Draffin & Collins 339-341 and 350-353), will tend to force the curved column into a greater curve, which could eventually cause failure by bending. The tensile forces carried by the muscular tensile members counteract the tendency of the column to bend under the vertical load, thus holding the curved column nearly straight (minimally curved) so it can go into more of a curve as it distorts in the process of absorbing sudden vertical loads or shocks and then the muscle tensile members can return the column to the original shape in preparation for another sudden vertical load or shock. Contracting the lumbar Spring Muscles™ reduced the angle of the vertebra surfaces by 9 degrees total in the following locations: between L2 and L3: 2 degrees, between L3 and L4: 1 degree, between L4 and L5: 0 degrees, between L5 and S1: 6 degrees as measured on a x-ray of the lumbar spine of the test body.

To sum it up, a doctor would say that the spine should be curved to absorb shocks (Levin-Gervasi)[2], but an engineer would say that the spine should be held nearly straight (minimally curved) by specific muscles so it can go into a greater curve in the process of absorbing mechanical shocks and then, using those specific muscles, return to the nearly straight (minimally curved) form in preparation for another possible shock.

The principle that certain muscles operate primarily in spring systems, as discussed elsewhere in other publications, in additon to the spinal springs has been applied to the shoulder spring and foot arch spring.

INCREASED LOAD CARRYING CAPABILITY

Per Euler's Formula, developed in 1759, the longer a column is in relation to its cross section, the more likely it will fail in bending (Draffin & Collins 339-341 and 350-353). By applying this principle, when we brace the middle of a column against bending, we increase its axial load carrying capability. An example of this in engineering design is a tall, slender television transmission tower with guy wires to the ground. The guy wires act as braces, in effect reducing the length of the column of the tower in relation to the cross section, thus increasing its axial load carrying capability. Drawing No. 3 shows an example of this and what happens when some of the guy wires are broken. An example of this in the body can clearly be seen in the anterior cervical (Gray 462) and posterior lumbar (Gray 467) views where in the cervical region the <u>scalenus anterior</u>, <u>scalenus medius</u> and <u>scalenus posterior</u> and in the lumbar region portions of the <u>quadratus lumborum</u> (from the spine to the pelvis) voluntary muscles can be used to brace the spine against lateral bending or scoliosis.

This same principle can be applied to lateral views of the spine where the Spring Muscles™ can brace the spine against excessive anterior (cervical and lumbar) or posterior (thoracic) bending, thus increasing the axial load carrying capability of the spine and creating additional stability. This principle can be seen in Drawing No. 4.

REDUCED CONCENTRATED LOAD ON DISCS

As discussed in the Appendix, when a column bends under compressive axial load there will be a compressive load on the concave side of the curve and a tensile load on the convex side of the curve. This means that for any one axial load, the compressive load per square unit (i.e., square inch, square centimeter, etc.) on the concave side of the curve will increase as the curve increases. Since as bending increases, the compressive load becomes more concentrated on a smaller area and thus the yield point (i.e., point of structural failure; here it would be in compression) of the supportive material may be reached or exceeded. Thus, the load on the portion of an intervertebral disc toward the concave side of the spinal curve can increase with bending. This could explain why in clinical situations the tendency is for the cervical and lumbar disc to herniate posterolaterally (White and Panjabi 5), which White and Panjabi (5 - 6) stated, "...must depend upon certain loading situations other than compression (assuming that uniform stress prevails in the disc under compressive loading)." As can be observed by the above explanation, uniform stress on the disc in compressive loading does not prevail.

To reduce the concentrated compressive load on an intervertebral disc for any one total load on the spine, decrease the curve of the spine, thus distributing the compressive load across more of the disc by increasing the contraction of the voluntary Spinal Spring Muscles™.

The bulging of the disc as observed in herniations may come from two possible sources. One is from creep as the elastic material deforms over extended periods of time. This can be observed in bonded rubber compression sandwiches (which is similar to the vertebra/disc compression sandwich) and calculations for same by Wahl (214-215). At higher concentrated compression loads, the tendency will be for the disc to increasingly bulge over time. However, by distributing the compression load across the entire disc by the use of the Spring Muscles™ the concentrated compression loads would decrease, thus reducing creep.

The second possible source of disc bulge as observed in herniations may come from irritation to living tissue due to the higher compressive loads brought about by the concentration of the load and the inflammation thus engendered. By reducing the concentrated compressive loads on the disc, this source of bulging could be reduced.

It has been observed in clinical situations that disc herniations occur most frequently in the cervical and lumbar regions and very infrequently in the thoracic region (Kambiz). Per structural theory, the herniations should also occur in the thoracic region because when the spine is allowed to curve with the concave side anterior, there is increased concentrated compressive load on the anterior side of the disc. Since the herniations in the thoracic region would usually be on the concave side of the curve, the spinal nerves on the convex side of the curve would not be intruded upon as happens when herniations occur in the cervical and lumbar portions of the spine. As the nerves are not intruded upon (causing pain) it may be that herniations DO occur in the thoracic region but patients seldom complain due to the lack of pain. This hypothesis should be studied clinically.

REDUNDANT LIGAMENT SYSTEM

That muscles provide the primary motive force controlling the movement, position and load bearing of bones while ligaments primarily provide a redundant system to prevent gross separation of bones at joints when muscles are not operational due to lack of voluntary control, maintenance, repair or damage is recognizable when redundancy principles are applied (Wong 6-9, 12-13, 62, 66-67, 74; Lewis 1-9, 216; Smith 3-9).

As we have already observed, muscles maintain the spine in a shape so that it is prepared to deform in the process of absorbing mechanical shocks and then return it to the original shape in preparation for another potential shock. We have also observed that muscles brace the spine against bending, thus increasing its static load carrying capability. These muscle functions are in addition to the motive force function.

Muscles also hold the vertebra bones tight in joint. In the spine one vertebra must be correctly positioned above the vertebra next down to maintain a distributed load on the disc. Should the vertebra become offset the distributed load would become more concentrated, possibly overloading the disc and causing other problems. It can be observed that when a movable vertebra bone from C2 downward is moved forward in relation to the vertebra bone immediately below, the facets meet, preventing the possibility of offset occurring. The angles of the facets can prevent lateral as well as anterior-posterior offset.

The voluntary multifidus spinae muscles span between the spinous process of a higher vertebra and the articular of transverse process of a vertebra one, two or three levels down (Gray 471). Thus, when the multifidus spinae contracts, the upper vertebra is moved forward in relation to the next vertebra down, thus causing the facets to meet preventing the vertebra bones from becoming offset. When the spine is twisted (left forward and right backward and vice versa) the facets of two adjoining vertebrae separate on one side and when the spine is brought straight again the multifidus spinae can be contracted, bringing the separated facets together again.

When the body twists to face left or right the spine deforms with the facets, on the side toward which the body twists, separating. When the body returns to facing forward the multifidus spinae can be contracted to pull the facets together again, once again preventing offset of the vertebra bones.

Thus it can be observed that when the muscles of the spine are operating there is no tensile load on the ligaments, except when the limit of movement of the joint is reached. It is essential that the ligaments carry no structural load when the joint position is between the limits of movement, otherwise there would be no possibility of joint movement. This principle can be observed throughout the body. Try this. Relax all the muscles operating the wrist joint so the hand flops. Using the other hand move the relaxed hand through all the range of motions (anterior-posterior, lateral and rotate) and notice that until the limit of motion is reached there is no load on the ligaments.

However, there are occasions when the muscles would not be operative. The individual may allow or direct the voluntary muscles to relax, s/he may be asleep so maintenance can be performed, a muscle(s) may be damaged, sensory or motor nerve controls to and/or from muscles may be damaged or untrained, etc. When such events occur the ligaments take over their redundancy function of keeping the vertebra bones approximately, but not precisely, in joint. This function can only be approximate as the ligaments must have a certain looseness to allow for joint movement as controlled by the voluntary muscles.

Another component of redundancy has to do with individual control. Control requires information from the equipment or environment to the operator. When engineering is applied to cars, means is provided for the driver (i.e., operator) to see brake lights on the car ahead so s/he can apply the brakes. An example in a body would be a weight lifter who is preparing to lift a weight to increase contraction of the Spinal Spring Muscles™ thus preventing bending of the spine, therefore making it possible to carry the additional load with no damage.

The individual may be warned of an overload on the backup system necessitating some corrective action. In a car the front brakes hydraulic system may fail leaving only the rear brake hydraulic system functioning, in which case the engineers provided a red warning light which turns on informing the driver of the failure. In such a case the driver would take the car to a repair shop. In the body the spine may curve to such an extent that the ligaments on the convex side of the spine are stretched to such an extent that mild pain ensues. In such a case the individual has certain options, several of which may be to put additional effort into contracting the Spinal Spring Muscles™, terminating the activity allowing the body to recuperate or visiting a doctor for professional corrective measures.

Redundancy principles can be applied to other muscle/bone/ligament systems of the body such as the shoulder, the foot arch, the elbow, the carpal tunnel area, etc.

SITUATIONS AND CONDITIONS POSITIVELY AFFECTED

Minor as well as major pains may be reduced or eliminated by correct operation of the Spring Muscles™. When the Spring Muscles™ are not operating and the redundant ligament system is carrying the load, the ligaments on the convex side of the spinal curve can stretch. The initial stretching can cause pain as a warning that the primary muscle system is off-line and some kind of correction, such as contracting the Spinal Spring Muscles™, is needed. An example of this can be observed by relaxing the muscles controlling the wrist and, uning the other hand, force the wrist to bend beyond its limits, thus stretching the ligaments until pain in the wrist is perceived. Should the correction not be taken, a heavier or longer duration load occur the ligaments could become damaged causing additional pain.

Also, pain can be caused by herniated discs pressing against spinal nerves and/or the thecal sac. Relieving the excess concentrated compressive load on the posterolateral portion of cervical and lumbar discs by using the Spring Muscles™ to as described previously could allow irritated disc to heal, thus reducing creep or inflammation.

Possibly via correct use of the Spinal Spring Muscles™ there could be prevention or correction of various conditions such as poor posture (cervical or lumbar spine hyperlordosis or thoracic spine hyperkyphosis), spinal disc herniations, facet syndromes, sciatic or other nerve lesions, Adam's Apple (thyroid cartlidge) protrusion or pregnancy back pain.

Compared to the above the following is minor, but as patient non-compliance is a major problem, it could increase the patient's willingness to go to the effort of developing control of the Spring Muscles™ and therefore should be stated. There could be increased height (1-1/2 inch in the test body was observed), improved posture and improved appearance including flatter abdomen.

APPLICATION OF TECHNIQUE

These instructions were developed to correctly operate and confirm operation of the Spinal Spring Muscles™ at any place, at any time without the use of special equipment and has been published in a layman’s level book. We will start with the cervical area. First, the cervical Spring Muscles™ are the longus colli, which are very deep in the anterior portion of the neck and are not palpable from the surface of the skin due to overlaying muscles. To perceive compliance, place the finger tips on the posterior cervical spinous processes in a spread pattern so as to sense the entire cervical curve. Contract the cervical Spring Muscles™ to such an extent that the finger tips perceive the cervical spine is posteriorly convex. This negates the curve and is sometimes called a Stovepipe Neck, but it gives a starting point. Next, relax the cervical Spring Muscles™ totally so the finger tips perceive the cervical spine to be posteriorly concave. Once again contract the cervical Spring Muscles™ so the finger tips once again perceive the spine to be posteriorly convex. Finally, relax the cervical Spring Muscles™ just slightly so the finger tips perceive the cervical spine to be only slightly posteriorly concave. As a positive indicator of correct use, when the cervical Spring Muscles™ are being used correctly the Adam's Apple (thyroid cartilage) will withdraw into the structure of the neck. In this form the cervical spine has deformation potential for absorbing the energy of possible mechanical shocks and is braced against bending, thus increasing its strength.

As the thoracic spinal curve is reversed from the cervical, the thoracic Spring Muscles™ (spinalis thoracis and the semispinalis thoracis) are on the posterior side of the spine and the assistance of another person is often required in order to get a perception of their location. Have the assistant trace the approximate pattern of the thoracic Spring Muscles™ by lightly placing the finger tips on each side of the spine and moving them up and down on either side and right next to the spine from the top to the bottom of the thoracic area and slightly into the adjacent cervical and lumbar areas (one or maximally two vertebrae worth). The first step is to contract the muscles directly under the finger tips. Next, relax those muscles so the thoracic spine curves maximally anteriorly concave. Once again contract the thoracic Spring Muscles™ which are directly under the moving finger tips so the thoracic spine becomes as straight as possible or even a bit of a reverse curve. Then relax the thoracic Spring Muscles™ just slightly so the thoracic spine is nearly straight (minimally curved), with a very slight posterior convex curve. When done correctly the chin will move posteriorly and the chest will move anteriorly in the classic “chin in and chest out” posture. It may be that the patient will perceive a posterior tilt in the overall body balance. In such a case, using the ankles as a fulcrum, adjust the balance in an anterior direction until equilibrium is achieved.

To learn to use the lumbar Spring Muscles™, the erector spinae along with its extensions longissimus thoracis and iliocostalis lumborum, first rock the pelvis several times so the pubis is maximally anterior and then maximally posterior, find the extremes, then find the approximate midpoint and place the pelvis there. Next, have an assistant trace the Spring Muscles™ with the finger tips several times. The patient should then use a hand to perceive the curves of the lumbar spine by placing an index finger vertically against the posterior lumbar spine. Then, once again rock the pelvis so the pubis is moved anteriorly and use the vertical finger to perceive that the lumbar spine becomes straighter (less curved). Return the pelvis to the midpoint and perceive how the lumbar spine is now concave posterior. Next, do exactly this: “keeping the pelvis in the midpoint, contracting the lumbar Spring Muscles™, pull the lumbar spine as straight as possible.” When the patient has done this, check that the abdominal muscles are firmly contracted, as this is the test that the lumbar Spring Muscles™ are being used correctly. Then relax the lumbar Spring Muscles™ slightly.

The Spring Muscles™ should be used continuously, as described above, whenever sitting upright, standing, walking, running or otherwise vertical. It is similar to learning how to ride a bicycle. At first the student has to totally concentrate on riding the bicycle, but eventually it becomes a habit and the rider can then take continuous attention off the bike riding, watch the scenery and carry on a conversation while riding the bicycle. The same applies to learning how to use the Spinal Spring Muscles™.

When teaching patients, the overall theory should be presented in a simplified manner without medical terminology so as to make it more easily understandable to increase the willingness to put forth the required effort. Then the actual “how to” is taught, also in simple layman’s terms. After all, it is a recognized phenomenon that patients often do not follow doctor's instructions (Groner). There is a copyrighted layman’s level book and website presenting the theories described herein as well as expansions of the theory to other portions of the human body already available and there will be a layman’s level DVD video forthcoming to assist in teaching patients.

SOME POSSIBLE PROBLEMS AND TENTATIVE SOLUTIONS

The most obvious possible problem is insufficient muscular strength and/or endurance. The solution would be a standard strength and/or endurance training program for those specific muscles until the springs are usable, at which time merely using the springs continuously would be sufficient for maintenance.

Myotome weaknesses sometimes occurs because of neuromuscular causes; spinal manipulation and/or low level laser therapy commonly can correct this problem.

There are many possible problems which could hinder the application of this discovery. The following are some which have surfaced to date. There may well be others.

Voluntary muscles may not be controllable. This could be anywhere from total paralysis to simply never having used them. For instance, one award winning body builder couldn't operate the lumbar Spring Muscles™. He was directed to lay on his belly and do a rocking chair by raising his legs and upper torso off the floor and rocking. This exercise forces the use of the lumbar Spring Muscles™. After a couple days of this exercise he was able to operate his lumbar Spring Muscle™ correctly.

The test body had a paralyzed cervical muscle (due to an accident) which was controllable when the head was turned totally toward one side. So, every day the head was turned to that side, the muscle was operated and the head was slowly turned toward forward until control of the muscle was lost. Day by day the range of control of the muscle was increased. This was repeated every day and eventually total control of the muscle was regained.

Sometimes an unintended muscle will operate at the same time as an intended muscle. This happened in the test body. The offending muscle was touched to identify which it was and the intended muscle was slowly, gently operated while at the same time attention was put on not operating the unintended muscle. Eventually the controls of the two muscles were separated. Doctors and physical therapists have other techniques to regain control of unusable muscles.

If the muscles on one side of the body are not being used there will be a twist. It has been found that sometimes the entire length of a muscle is not operating. Once identified, the muscles need to be trained to operate correctly. Along the same line, using only part of the muscle, such as only the middle and not the ends of the Neck Spring Muscle™ which attaches to all the cervical vertebrae, can cause distortions of the cervical spine.

In some cases there may have been injuries preventing correct operation of the system. For instance, a severed or torn right iliocostalis lumborum could prevent the lumbar Spring Muscle™ from operating correctly. Such a condition could require surgery for correction.

Fused vertebra bones could prevent use of the spinal springs unless artificial intervertebral discs were installed.

The patient may merely be lazy and not continually maintain use of the Spring Muscles™. There are a couple handlings. One is to focus on just one area, such as the cervical, at a time and not continue onto another until that is used habitually. Another is to go over the theory and get the patient's agreement that this is important and will undertake to put forth the required effort. Another is to attend an exercise class where the student is constantly reminded to use the correct muscles. Eventually a habit could be formed.

CLINICAL STUDY

A five (5) week clinical study on five (5) persons was done using the Revised Oswestry "Low Back Pain and Disability" questionaire. Below is a summary of each person. Typically the questionaire was filled out before the teaching of the theory of the lower back spring muscle™ and how to apply it, immediately after the teaching, a week later, two weeks later and again two weeks later although often the questionaire was not done precisely on time.

The questionaire has two sections. The first section pertains to Activities of Daily Living (ADL's) while the second section pertains to the Pain Severity Scale. In each section the lower the score, the better off the study participant is. The range of the first section is from 0 to 100 and the range of the second section is from 0 to 10.

The first participant, D.R., had the following scores on the ADL's: Before: 8; After: 10; First week: 10; Third week: 1; Fifth week: 0. On the Pain Severity Scale this participant had: Before: 1; After: 1; First week: 1; Third week: 0/1 (both numbers on the questionaire were enclosed in one circle); and for the Fifth week, again 0/1.

The second participant, D.B., had the following scores on the ADL's: Before: 24; After: 22; First week: 18; Third week: 10; Fifth week: 18. On the Pain Severity Scale this participant had: Before: 2; After: 2; First week: 1; Third week: 1; and for the Fifth week, again 1.

The third participant, H.C.C., had the following scores on the ADL's: Before: 24; After: 24; First week: 6; Third week: 12; Fifth week: 10. On the Pain Severity Scale this participant had: Before: 3; After: 2; First week: 1; Third week: (no answer); and for the Fifth week: 1.

The fourth participant, R.B., had the following scores on the ADL's: Before: 24; After: 20; First week: 24; Third week: (missed filling out questionaire due to being unavailable); Fifth week: 12. After the first week it was found that this participant was not capable of having control of the lumbar Spring MuscleTM. The participant was given instruction to use the rocking chair exercise described previously in this paper. On the Pain Severity Scale this participant had: Before: 1; After: 0; First week: 4; Third week: (missed filling out questionaire); and for the Fifth week: 3.

The fifth participant, J.L., had the following scores on the ADL's: Before: 36; After: (did not fill out questionaire - the participant was instructed on the telephone and there was no way to ensure that instructions were carried out); First week: 22; Third week: 34; Fifth week: 14. On the Pain Severity Scale this participant had: Before: 4; After: (did not fill out questionaire); First week: 6; Third week: 7; and for the Fifth week: 3.

It can be observed that in two cases the last questionaire(s) showed some worsening which could be attributable to neglect of application of the theory - a typical problem observed clinically. On the whole the clinical study shows improvement over the course of the study.

POSSIBLE DISTRIBUTION OF THIS TECHNOLOGY

Many people can learn and apply this technology just by knowing and using it. However, there are others who need additional help. We guesstimate that 20% to 25% of the population would need professional assistance in getting this to working for them.

Classes could be held in gyms, workout studios, dance studios, by personal trainers, etc. and those who need help sent to physicians. Sport coaches could teach it to their players to help prevent sports injuries. Middle and high school health instructors could add it to their curriculum. Ideally instruction and training would start in kindergarten which may prevent possible deformation of maturing skeletons (White and Panjabi 366 and Fig 7-22). Industrial accident prevention classes could also be held. Pregnant women could be taught this to prevent pregnancy lower back pain. Of course, physicians could hold basic classes in their own offices, but that would require systems setup which most doctors are not currently able to handle. In reality, physicians of various disciplines or physical therapists would best handle the one-on-one problems which cannot be handled in a typical class.

Although engineering basics and simple experiments have already been used to develop use of these as well as other muscle/bone/ligament systems throughout the body including the feet (plantar fasciitis, heel spurs, shin splints), shoulders, and other areas (tennis elbow, capral tunnel syndrome), detail theory and clinical research is still needed to develop detailed knowledge and optimum application to the human body.

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APPENDIX

SOME ENGINEERING BASICS

We really should define some basic engineering terms to which we will be referring in this article.

"Force may be defined as that action of one body on another body which causes or tends to cause a change in the shape or motion, or both, of the second body."

Concentrated forces "...act over small areas such as the wheels of a truck on a floor..."

Distributed forces are "...spread over a considerable area, such as snow on the roof of a building" (Draffin and Colling 3).

Tensile forces "...tend to elongate the member on which they act..."

Compressive forces "...tend to shorten the member" on which they act (Draffin and Collins 5; also 107 for tension and compression).

Shear is where two parallel forces acting on a body are equal in magnitude and opposite in sense (i.e. "...which way along a line of action the force is acting." Draffin and Collins 4) but not in the same straight line..." (Draffin and Collins 108).

"A beam is a body which has a length greater than its cross-sectional dimensions, which is supported at one or more points along its length and which supports transverse loads."
A simple horizontal beam is supported vertically upward from below at each end, with the ends free to rotate and with a vertically downward force from above somewhere between the ends (Draffin and Collins 214). It is known from experiment that in such a beam "...the top portion will be in compression, i.e., it will be pressed together or shortened, and the bottom portion in tension, i.e., it will be pulled apart or lengthened." The beam will be bent with the top surface of the beam concave and the bottom surface convex (Draffin and Collins 216 - 217).

"A column ... is a member, vertical, horizontal or inclined, to which compressive forces are applied in a longitudinal direction [i.e., along the axis, an axial load] and in which the length is relatively great with respect to the lateral dimensions." "It is a matter of common experience that for the same kind of material and a given cross section, the longer a column is the easier it will bend and fail; furthermore, it will usually bend in the direction of the least lateral dimension." (Draffin and Collins 329)

As with a beam, when a column bends or deflects under load, the convex side will be under a tensile load and the concave side will be under a compressive load.
A compression block is short and stocky, if of ductile material will fail by plastic deformation and if of brittle material by shear. (Draffin and Collins 330).

A long, slender column will "...fail suddenly by bending elastically..." (Draffin and Collins 330 - 333).

Stresses are "...internal or resisting forces brought into action in the parts by the external forces or loads" (Draffin and Collins 105).

Deformations or strains are "...the changes in size and shape of the member as a result of the application of external forces" (Draffin and Collins 105).

Static loads are "...where the load is applied slowly and either remains on the structure indefinitely or is removed and reapplied only a relatively small number of times during the life of the structure" (Draffin and Collins 105-6).

Repeated loads are applied and removed, applied and removed again and again "...a very large number of times during the life of the part" (Draffin and Collins 106).

Impact or energy loads are suddenly applied loads (Draffin and Collins 106).

An axial load is "...a central load that acts along the axis of a member" (Draffin and Collins 106).

The modulus of elasticity "...for many materials, within certain limits..." is "...a constant or nearly constant relation between the unit stress and the corresponding unit strain." It is based on Hooke's Law, first announced in 1678, which states that straight wires, coiled and helical springs elongate "...in proportion to the load applied." This is valid within certain limits (Draffin and Collins 116).

The yield point is where the material "...deforms without any increase in stress" (Draffin and Collins 131).

The Euler Formula was developed by Leonardo Euler (1707-1783) in 1759 and was the initial column bending formula upon which all subsequent column formulas for varying height-cross section and cross section shapes are based. (Draffin and Collins 339-341, 350-353)

Properties of materials relevant to the "...elementary study of load-resisting bodies": 1.) strength: the "...ability to resist force"; 2.) ductility: the amount of deformation a material can undergo prior to failure - brittle is little deformation and ductile is much deformation prior to failure which allows "...a readjustment of the stresses to take place"; 3.) toughness: "...the measure of the maximum ability of a material to absorb energy"; 4.) resilience: the ability "...to absorb energy without significant permanent deformation"; 5.) stiffness: "...the property which enables a material to resist deformation"; 6.) hardness: the ability to resist indentation, abrasion or grinding and cutting; 7.) creep strength: creep "...is the deformation or flow that continues indefinitely when the material is stressed." Creep strength "...is, for any given temperature, the maximum unit stress that can be developed in the material during a specified length of time without causing more than a specified deformation..." - "the time required for one creep test is usually at least 10,000 hr.. and the results of such tests are then extrapolated to the lifetime of the part, perhaps as much as 20 years." thus short time tests at room temperature become meaningless under conditions of creep; 8.) endurance limit: "...the maximum unit stress that can be repeated, through a definite cycle or range of stress, an indefinitely large number of times without causing the material to rupture...." or more simply: "...a load is repeated, applied and released, an indefinitely large number of times" - a small portion, such as a crystal, a small failure developed and then the small failure extends with each repetition until total failure occurs (Draffin and Collins 130 - 154).

A common suspension bridge typically has a main curved cable suspended between two high points with vertical cables suspended down to carry the roadway, sitting on what is structurally a girder (a large beam) (Pugsley 42, Steinman) By definition, the suspension members are carrying tensile forces.

"A mechanical spring may be defined as an elastic body whose primary function is to deflect or distort under load (or to absorb energy) and which recovers its original shape when released after being distorted." (Wahl 3)

"It is a fundamental tenet of reliability engineering that as the complexity of a system increases, the reliability will decrease, unless compensatory measures are taken." - "An alternative to the requirements for components of increased reliability is to provide redundance in part of all of a system" (Lewis 216).

"Reliability engineering concepts": 1.) reliability: "...duration of failure-free operation under specified conditions (not misused)"; 2.) failure: "...a loss of function of a machine or system"; 3.) fault: "...non-conformance that needs unscheduled maintenance for correction"; 4.) availability: "...duration that a machine or system is able to function as required for the period under consideration"; 5.) maintainability: "...the time it takes to repair a fault and return a system or machine to being available for operation"; 6.) safety: avoidance of "...failures that could affect health or result in injury..."; 7.) probability: "nothing is certain..." - reliability "...cannot be predicted with certainty" (Wong 8).

"The odds against failure can only be improved by adding redundancy and diversity" (Wong 12).

"Operators may by-pass a safety system for some reason and think that the hazard will not occur. One day it will and disaster strikes" (Wong 13).

The operator must have knowledge of the operation of the machine and be provided with timely data about the operation and condition of the systems. Too much data is as dangerous as too little data (Wong 61 - 73).

"Maintainability also contributes to the availability of a system, since it is the combination of failure rate and repair/down time which determines unavailability" (Smith 7).

There are many more details, principles and formulas used in engineering that are not needed in this introductory article.

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END NOTES

[1] Note that the muscles identified in this text as spring muscles are voluntary in that in the test body they are subject to voluntarily contraction and the voluntary nature has been achieved in others to whom this has been taught.

[2] "Without these curves the spine would not have the strength and resilience to act as a shock absorber during movement. The back's curves are designed to absorb shock.... The natural curves act as a coiled spring to absorb force or jarring during activity." (Levin-Gervasi)

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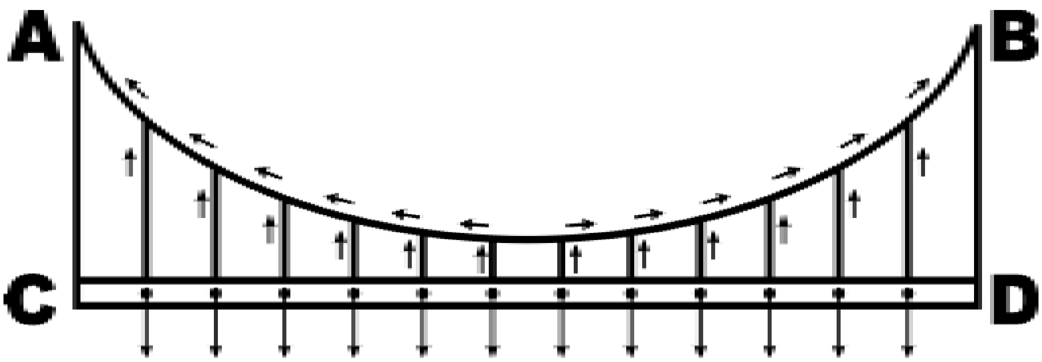

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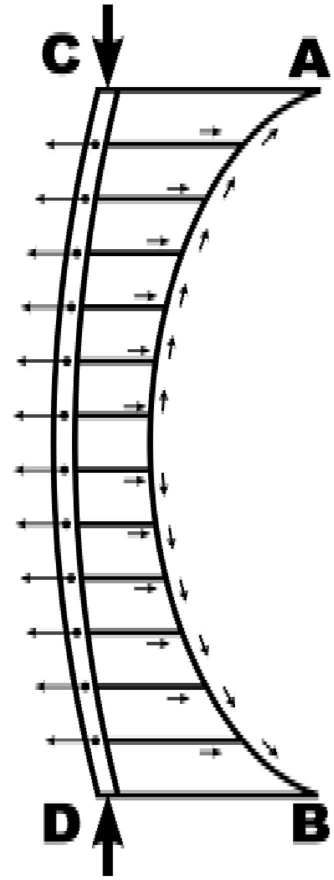

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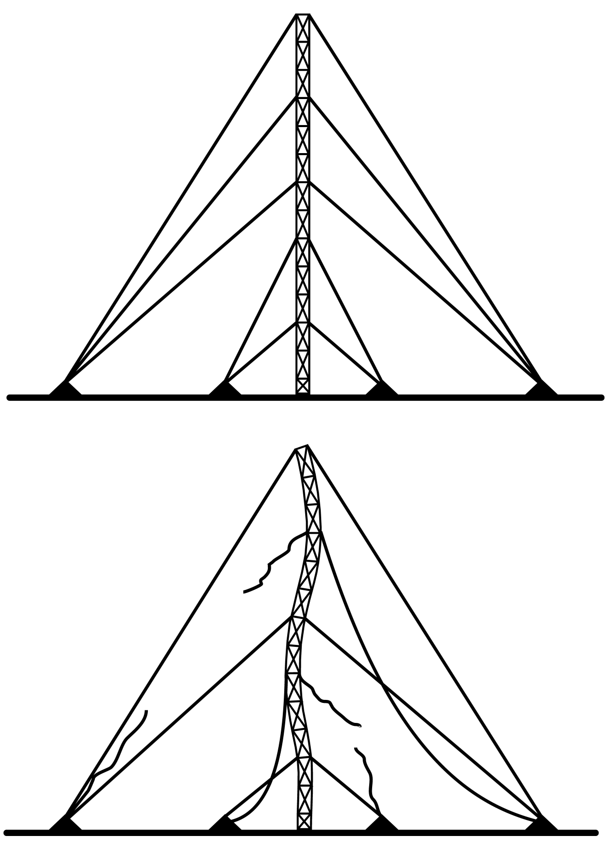

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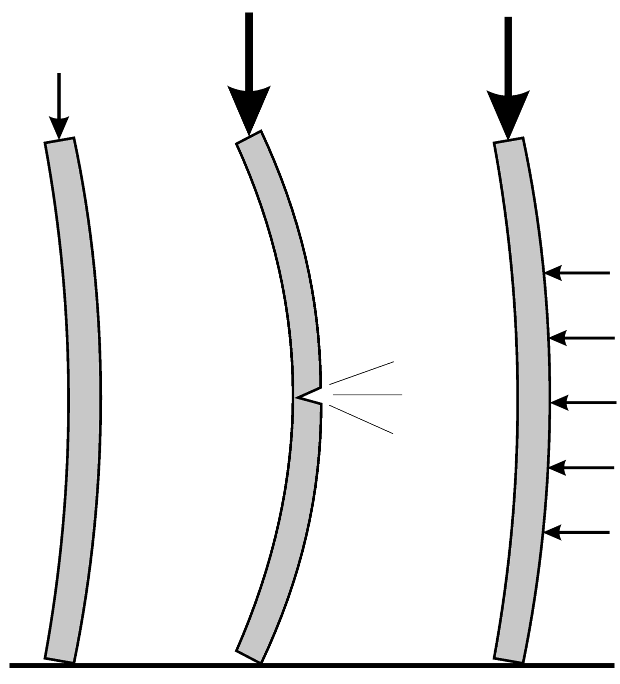

Drawing 4