MedX Medical Machine ....Theory and Operation

MedX Lumbar Extension Machine, left.

Below, MedX Cervical Extension Machine.

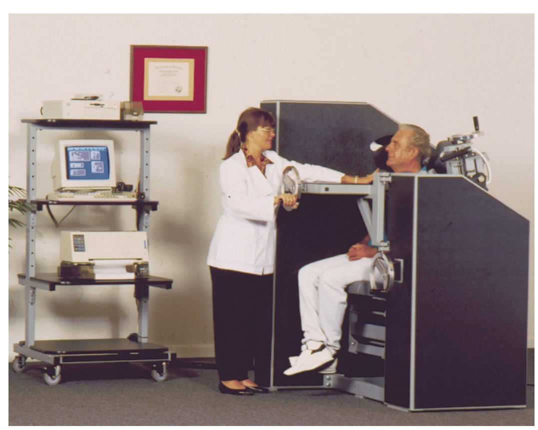
This training manual is intended to equip its student with machine-operation skills and an understanding of MedX theory for effective medical exercise and musculoskeletal rehabilitation. It aims to provide competent clinicians a command of MedX-based technology for treating spinal pathology in both the cervical and lumbar regions.

This educational program is a predecessor of one previously conducted at the University of Florida, Center for Exercise Science, started in 1988 and running continuously through June 2003.

The personnel responsible for this program were students in one or more spinal certification classes at UF, and have worked with MedX technology for more than two decades combined.

Program Objectives

1. To effectively operate MedX-based medical exercise and rehabilitation facilities, directors and clinicians require proficiency in the following:
   A. Skeletal and muscular anatomy, physiology and function of the lumbar and cervical spine.
   B. Identification of machine parts and proper operation of MedX strength testing equipment.
   C. Proper body positioning and stabilization during strength testing/training.
   D. Strength curve interpretation.
   E. Computer (software) operation.
   F. Clinical aspects of strength testing/training.



Proper operation of the equipment is best learned through hands-on instruction by a knowledgeable clinician, company representative, or independent party certified through the University of Florida or the University of California at San Diego. This reference manual complements the hands-on instruction.

Definitions of Commonly Used Terms

Acceleration – the upsloping of an isokinetic strip chart recording when moving from 0°/sec to the preset speed of the machine. Muscular torque is not recording during this period, which can account for 30-50% of joint ROM.

Acute pain – the result of some specific and readily identifiable tissue damage.

All-or-none principle – the fact that either all of the muscle fibers within a motor unit contract or none of them contract.

Atrophy – the reduction in the size of muscle or muscle group (a normal response to disuse or immobilization).

Basal metabolic rate – a minimum level of energy required to sustain the body's vital functions in the waking state.

Calibrate – the process of setting a measurement device equal to a known reference point prior to collecting data.

Chronic pain – decline in symptomatic recovery despite assumed completion of tissue healing following initial trauma. A condition generally becomes chronic 8 to 12 weeks after onset.

Compound trunk function – extension or flexion of the trunk which incorporates primarily the hip extensors (hamstrings and gluteals), and secondarily the lumbar extensors (72°) for a complete movement of 180°.

Concentric muscle contraction – the muscle shortens as it develops tension and overcomes external resistance.

Constant resistance – there is no alteration of the resistive torque throughout the joint's ROM. This is generally achieved through the use of a round pulley.

Correlation coefficient – describes the relationship between two or more variables, and is expressed statistically as 'r'. r can range from +1.0 to –1.0, and is often used to express the reliability of test/retest measurements.

Dampening – a method by which torque overshoot (impact force) is attenuated or eliminated during the computerized reporting of an isokinetic test result.

Deceleration – the downsloping of an isokinetic strip chart recording what occurs toward the end of a joint ROM as a result of proprioceptive protective mechanisms, which slow down a muscular contraction. Decrease in an object's velocity per unit time.

Degrees per second (°/sec) – the unit of measurement used to describe limb velocity during isokinetic testing.

Eccentric muscle contraction – a muscle lengthening while developing tension as a result of the external resistance exceeding the muscular force generated.

Fast twitch muscle fiber – type of skeletal muscle which is characterized by the ability to produce powerful contractions over short time periods. These fibers have very little capillary and mitochondrial densities and low aerobic capacity.

Fatigue Response Test (FRT) – An isometric test, followed immediately by a set of dynamic exercise, followed immediately by another isometric test. The shape of both curves should be very similar, although the post-exercise test should produce lower torque.

Flexibility – the looseness or suppleness of the muscles, tendons, ligaments and joint.

Impact force – a force produced against the limb as a result of the braking action (servo-mechanism) of an isokinetic machine. Such forces are recorded as torque overshoot on an undampened isokinetic report and are potentially harmful to the joint system being tested.

Inroad – the loss of isometric strength, generally as a result of an acute bout of dynamic exercise (fatigue response test).

Isoinertial – a term synonymous with isotonic.

Isokinetic resistance – (‘iso’ = same, ‘kinetic’ = speed) in theory, a maximal muscular contraction performed at a constant angular limb velocity. There is no set resistance to meet. Any force applied against the equipment results in an equal reaction force. The reaction force mirrors the force applied to the equipment through the range-of-movement. However, because of accleration/deceleration and torque overshoot, the term ‘isokinetic’ is a misnomer.

Isometric contraction (static) - (‘iso’ = same, ‘metric’ = length) a muscular contraction where no change in the length of the muscle takes place. This can be performed against an immovable object such as a wall, a barbell, or a weight machine loaded beyond the maximal concentric strength of an individual.

Isotonic contraction - (‘iso’ = same, ‘tonic’ = tension) in theory a muscular contraction in which the muscle exerts a constant tension against an external resistance that does not vary. The term ‘isotonic’ is a misnomer because the amount of force that a muscle must generate to overcome a fixed external resistance will change due to the biomechanical arrangement of the bones, joints, and muscles at each joint angle (change in leverage).

Law of levers – Reistance X Resistance Arm = Force X Force Arm.

Learning effect – the process of becoming familiar (efficient) with a movement as a result of performing that activity. This can include psychological and physiological adaptations. Relatively permanent improvement in behavior as a result of practice or experience.

Mean – an average of scores.

Mechanical work – energy output expressed as a force (F) acting through a vertical distance (D). Work = F X D.

Metabolism – the sum of all the biochemical reactions that occur within an organism.

Motor unit – an alpha motor neuron and all of the muscle fibers it stimulates. The functional unit of muscular activity under neural control.

Muscle function – the ability of a muscle to generate force.

Muscle hypertrophy – a normal response to exercise training and is characterized by an increase in the size (cross-sectional area) of the individual muscle fibers.

Objective measurement – one in which the evaluator's personal opinions cannot bias the test results.

One repetition maximum (1 RM) – the maximum amount of weight an individual can lift through their full ROM one time (common form of isotonic testing).

Psychosocial function – how an individual views himself/herself and how he/she interacts with others.

Range-of-motion (ROM) – a joint's capacity to move from one position to another. ROM is dependent upon the structure of the bones comprising the joint, the length of the muscle ligament, the elasticity of the tendinous tissue, and the distribution of body fat.

Reliability – repeatability (consistency) of test measurements.

Servo-mechanism – the part of an isokinetic machine that functions to brake an accelerating limb.

Slow twitch muscle fiber – type of skeletal muscle that is characterized by low-force production that can be maintained over long periods of time. These fibers have very high capillary and mitochondrial densities and can sustain endurance activities.

Spinal stenosis – a narrowing of the spinal canal producing compression of the cauda equina (nerve root).

Spondylolysis – fatigue fracture of the vertebrae.

Standard deviation (S.D.) – an estimate of the variability or spread of the data; variability of scores from the mean.

Standard error of the estimate (SEE) – a description of the variation between the relationship of two or more variables.

Subjective measurement – one in which the evaluator's personal opinions can bias the rest results.

Synergistic muscle activity – stabilizing muscular activity which serves to steady a movement during contraction thus preventing unwanted movements and helping the target muscle group to function more efficiently (e.g. free weight lifting).

Torque – a force acting upon a lever (moment) to cause rotation about a fixed axis (Torque = Force X Distance).

Torque overshoot – testing artifact produced by the servo-mechanism of an isokinetic machine when it brakes an accelerating limb in an attempt to maintain a preset speed of movement.

Validity – accuracy of a measurement; (ie. The device measuring what it is supposed to measure). Validity = calibration.

Variability – a statistical description of the speed of the data; deviation from the mean (e.g. S.D., S.E.E).

Requirements for Valid Testing

Accurately testing torque generated by the muscles that extend the spine requires eliminating or accommodating several factors that would otherwise nullify validity of the results. More than a dozen years of research and development were dedicated to what has resulted in today's MedX Medical Lumbar Extension and Medical Cervical Extension machines. Most of the time was spent in trial-and-error experimentation identifying — and ultimately gaining control over — these factors.

Today's clinician, unaware of the painstaking past, may fail to recognize the significance of one or more of the measures necessary for assessing or eliminating artifacts that skew test data. This results in compromising MedX medical machine technology and shortchanging the patient. Attention to detail and appreciation of seemingly insignificant directives matter more than you may realize.

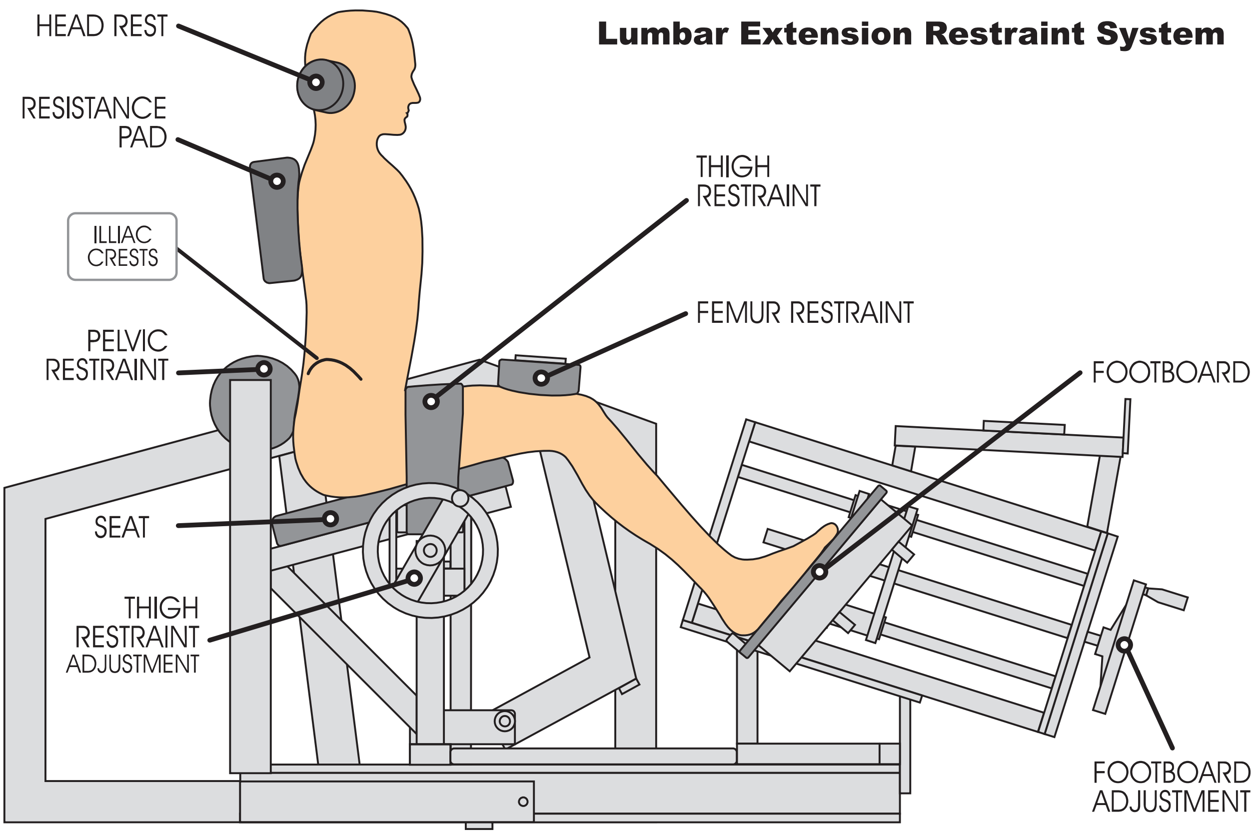
Developing equipment capable of performing meaningful tests of strength, range of motion and muscular endurance signified a breakthrough in treatment of musculoskeletal dysfunction. MedX revolutionized rehab of the spine by incorporating the features highlighted on the following pages into its machine designs and operation procedures.

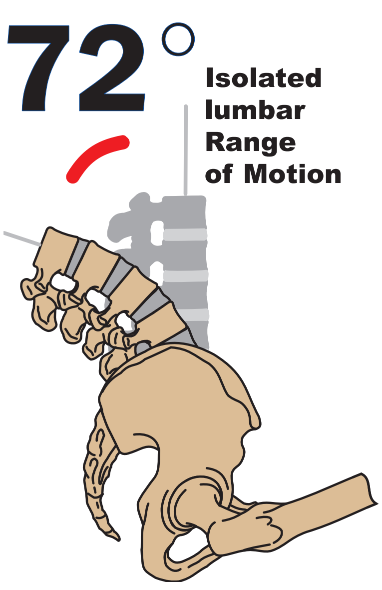
The benefits of this experience are provided in this reference training manual. Please consider carefully all requirements and suggestions.

1-A. Pelvic Stabilization/Immobilization

(Lumbar Extension)

An elaborate pelvic restraint mechanism is built into the Lumbar Extension Machine. Its appropriate application is easily identified visually — if the tubular pads compressed against the patient's pelvis rotate on their own axis, the hip and thigh muscles are producing measured torque. Tighten the restraints until the pads fail to rotate when the patient flexes and extends through the range of movement. (See "104-Point Checklist" for further information)





The lumbar extensors muscles are isolated in the following manner:

1. Force imposed against the bottom of the feet is transmitted by the lower legs to the femurs at an angle of approximately 45 degrees.

2. Large pads located above the lower thighs limit upward movement of the knees.

3 . A heavy belt prevents upward movement of the upper thighs and pelvis.

4. A round pad prevents movement of the pelvis in the direction of extension.

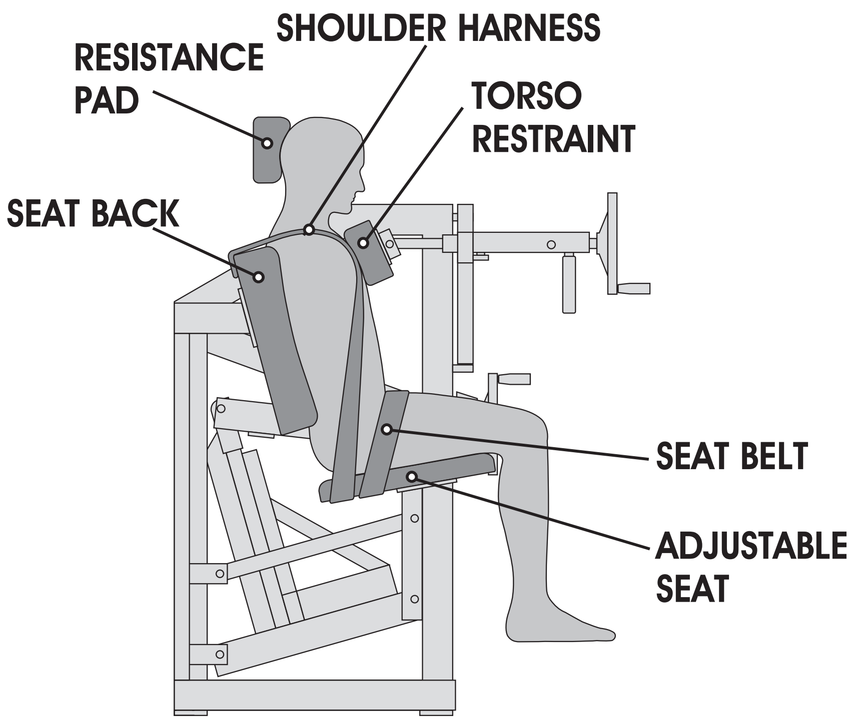
Properly restrained in this machine, the pelvis cannot rotate. It is the clinician's duty to check for pad rotation, and tighten restraints until it does not occur. Without total restraint of the pelvis, force from the muscles of the hips and thighs would contribute to torque readings, making it impossible to determine the true force-production capability of spinal muscles as well as range of isolated lumbar-spinal movement.

1-B. Torso Stabilization and Trapezius Restriction

(Cervical Extension)

To keep the cervical extensor muscles from receiving assistance from the trapezius muscles, a shoulder harness is applied over the patient's collarbone. This works in unison with upper chest padding and seat belt to anchor the torso, and thus isolate the cervical extensor muscles.

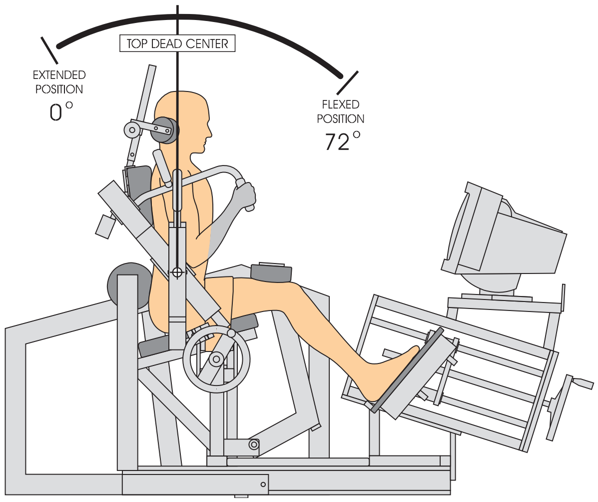
Cerivcal Extension Restraint System

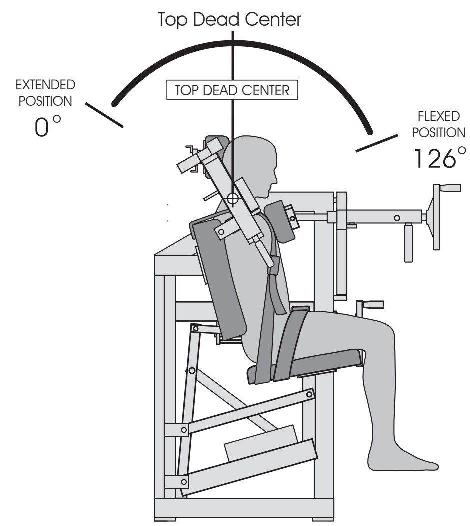


Restraint for cervical extension isolation is provided by a system that anchors the shoulders and torso. Vertical adjustment of the seat is provided to bring the effective axis of the neck into coaxial alignment with the axis of the machine. However, due to the spine's multi-hinge nature, the effective axis of the neck changes as it extends. Compensation for this change is provided by the resistance pad's freedom to rotate on its own axis. While this automatically compensates for any alignment shifting of the neck axis with the machine axis, movement of the pad should be very slight. Marked rotation of the pad as a patient moves from flexion to extension signifies need to adjust the vertical position (seat height). The seat should be cranked up or down until very little rotation of the pad is produced by full-range extension of the cervical spine.

2. Torso, Head and Aparatus Counterweight

To compensate for torque produced by gravity acting upon the mass of the head, arms, and torso, a counterweight must be positioned accurately to offset this force. Both the Lumbar and Cervical machines provide such a counterweight and it must be set appropriately for each testing or exercise session. On the Cervical Extension, every part of the machine that moves, apart from the weight stack, is also counterweighted.





1. Determine Top Dead Center

Before setting the counterweight, determine the centerline of torso mass (lumbar) and head mass (cervical). The counterweight is connected in an opposite direction; when the top dead center line is straigh up, the counterweight must be straight down; it's 180 degrees out of phase with the patient's midline of mass. The counterweight is connected to the resistance arm by a lock lever (which the therapist is holding at right). A bubble level indicator is also incorporated into the design to assure accuracy.

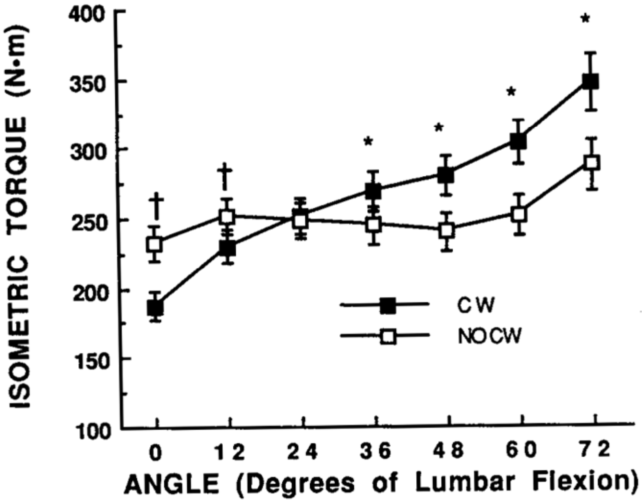
2. Set Couterweight

With the subject relaxed in the extended position, the counterweight is adjusted by turning this crank until balance is achieved; the weight of the body is balanced by the torque from the counterweight acting in an opposite direction. The computer monitors this operation, signalling when balanced.

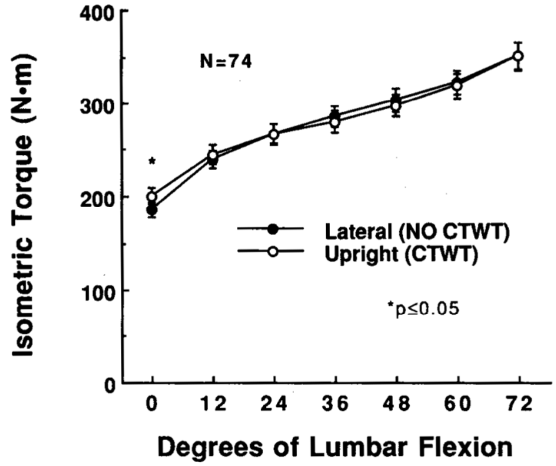
3. Record Settings

The goniometer (angle detector) on the right side of the machine indicates position of top-dead-center, and a digital position indicator on the counterweight shows position of the counterweight in which proper counterweighting was provided. Both of these readings should be entered into the computer record for future use with the particular patient. Barring meaningful changes in bodyweight, the top-dead-center setting and counterweight position will never change.

The Importance of Counterweighting



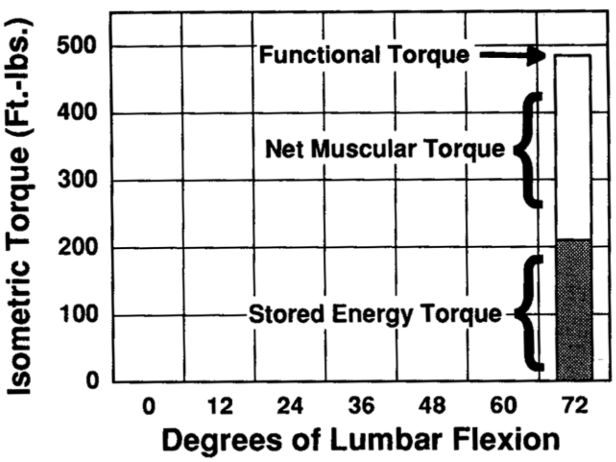
A group of 34 subjects was tested for isolated lumbar extension strength with counterweighting (CW) and again without a counterweight (NOCW). This graph demonstrates that the typical angle of top dead center is 24 degrees. From 72 degrees of flexion to 24, patients have to lift their torso weight, which is why the NOCW torque readings are lower in that range. Most subjects go "over the top" around 24 degrees, which means their torso weight is now assisting; conversely, a counterweight nullifies this assistance. (Presented at the Orthopaedic Rehabilitation Association Conference, San Antonio, TX, 1990)

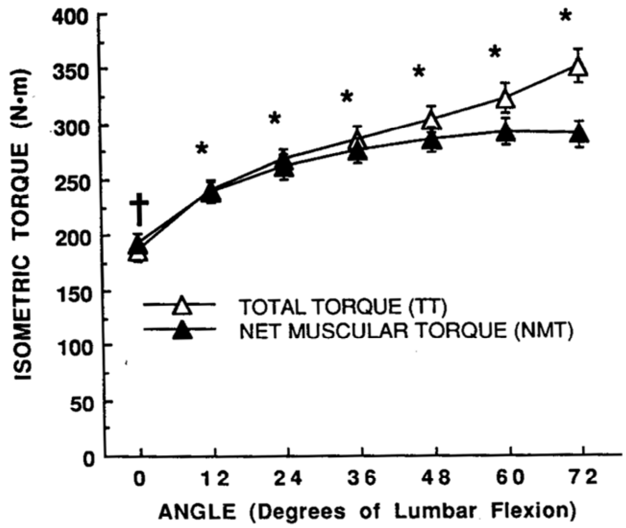


This chart shows the isometric torque values for lumbar extension strength testing in the sagittal plane with upper-body mass counterweighted (CTWT) and in the transverse plane without the need for counterweighting (NO CTWT). Notice that the values are essentially identical. (From Pollock M, Graves J, Leggett S, et al; Med Sci Sports Exerc 1991; 23 (suppl):66.)

3. Nonmuscular Torque Assessment

In addition to torque produced by the force of muscular contraction there are three sources of nonmuscular torque (gravity, friction, and stored energy). These sources of force-producing tension must be measured by the machine's computer and eventually deducted from torque measurement of the muscular contraction.





Stored Energy

Stored energy, one of the test options in the machine software, is determined by having the patient positioned at the testing angle but totally relaxed. Flip the force/angle switch to record a measurement. It will capture a force reading of the compressed tissue in the front and the stretched tissue in the rear of the patient's torso. The bar graph displayed on the monitor indicates the level of nonmuscular torque produced in that position. A large man, totally relaxed in the fully-flexed position, may produce more than 300 foot-pounds of nonmuscular torque which will overstate the true level of strength to an enormous degree.

Functional Strength

Having measured and recorded nonmuscular torque, the actual strength test begins by having the patient gradually produce muscular force in the direction of extension of the lumbar spine. As the level of effort increases, the monitor shows a rising bar graph of torque. Upon reaching a maximum level of effort, the patient should maintain that level for approximately two seconds, and then slowly relax. Muscular force should be increased and reduced slowly, without jerking. The maximum level of measured torque is functional strength in that position.

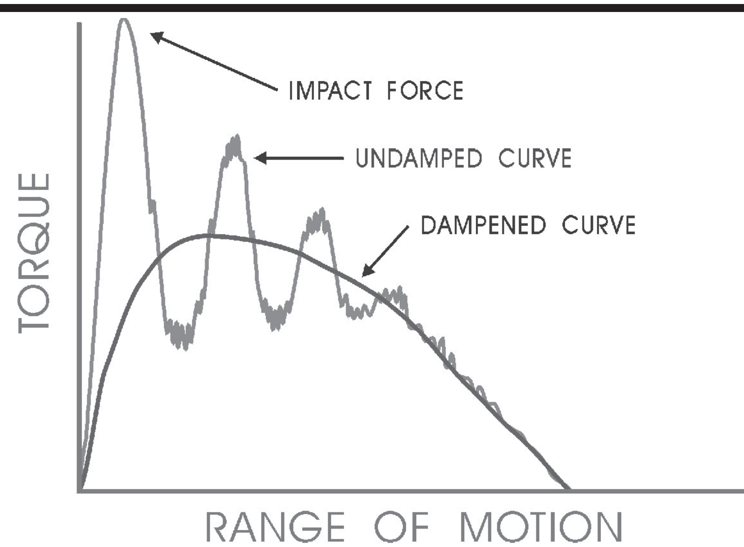
Net Muscular Torque

When nonmuscular torque is subtracted, the remainder is the true level of muscular strength, or net muscular torque (NMT). This is the amount of force actually produced by the muscles.

4. Isometric Testing Method

Accurate testing requires an isometric contraction with the generated force measured by a strain gauge. Static testing avoids the inherent difficulties of dynamic testing procedures. All dynamic procedures produce error in test results from several unavoidable sources: impact forces, friction and stored energy (torque produced by stretching and compressing soft tissues). Dynamic testing may also allow insufficient motor unit recruitment and spans of acceleration/deceleration may not allow for full ROM measurement. On MedX equipment, a succession of isometric contractions are performed along a series of standardized angular positions. These torque readings are then computed into a strength curve.

The graph at right was adapted from Murray, D. Optimal Filtering of Constant Velocity Torque Data. *Med Sci Sports Excer:* 18, 1986. It compares the impact force and the undamped and dampened curves during dynamic repetition testing on isokinetic-type equipment.



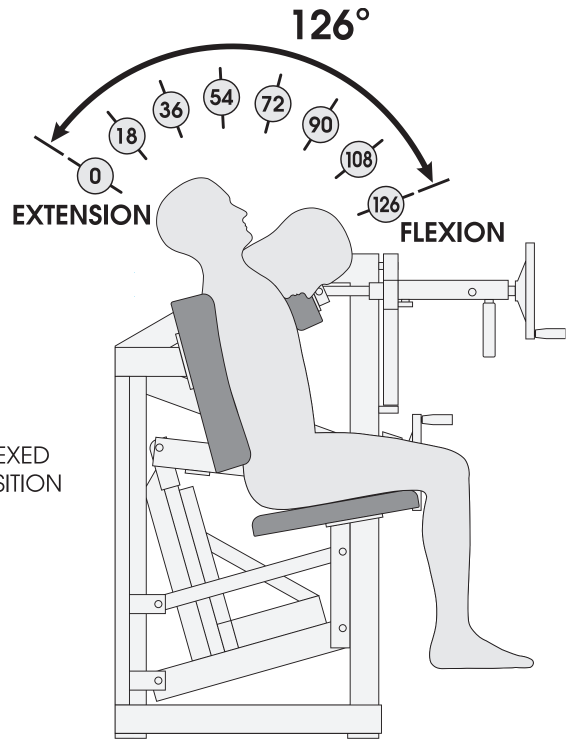
At the time of its introduction, MedX jolted orthodoxy by proclaiming “isokinetic” testing devices as unreliable. Several independent research studies were also pointing out inadequacies. Researchers who examined a Biodex Isokinetic device reported:

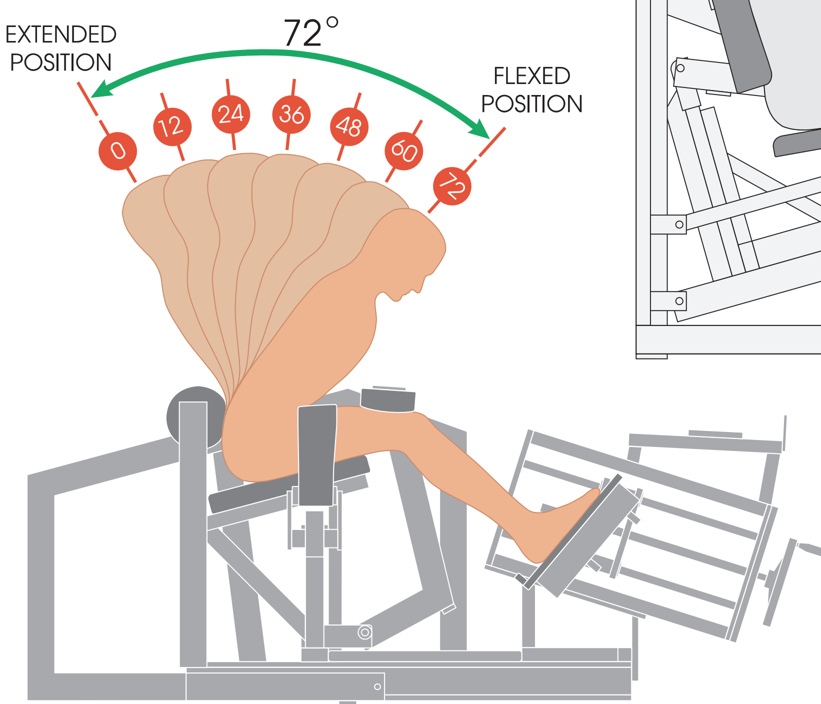
> “Because isokinetic devices test dynamic rather than static movements, clinicians may have assumed that these devices provide more meaningful (i.e., more functional) measurements than do strain gauges or cable tensiometers...The evidence in the athletic literature suggests that this is not the case. Relative to rehabilitation, there is no evidence to support the argument that dynamic testing is a better predictor of functional capacity than static testing....Future research may demonstrate some predictive use of isokinetic measurements, but at present, any suggestion that functional performance may be determined from isokinetic testing is conjecture.”
>
> – Mayhew, T., and Rothstein, J. Measurement of muscle performance with instruments. In Rothstein, J. (ed.) Measurement in Physical Therapy, 1985.

MedX pioneered static testing.

5. Repeatable Angular Positions

Due to leverage and biomechanical factors, strength output varies from one position to another throughout any full-range movement. Thus it is necessary to determine the relative positions of the involved body parts; true changes in strength can be determined only when the tests are conducted in known positions.





*On the **Cervical Extension** (above), normal range of movement is 126 degrees, and testing can be conducted in any of 43 positions, in increments of 3 degrees. Given a subject with full-range movement, testing is normally conducted in eight positions, in increments of 18 degrees throughout the full range.*

***Lumbar Extension** tests can be performed in any or all of twenty-five positions, with three-degree increments between adjacent test positions; thus it is possible to test within one and one-half degrees of any desired position. Typically, however, static tests are conducted in each of seven positions, at intervals of 12 degrees within 72 degrees of isolated lumbar-spinal movement.*

Equipment Anatomy

Lumbar Extension Machine Parts

A. Upper Back Pad
1. attached to movement arm, serves as the mechanism to which lumbar extensor force is applied
2. pad is counterweighted for accurate measurement
3. maximal amount of back (shoulder) surface area should be applied to pad

B. Movement Arm
1. lever arm of machine; rotates on machine axes
2. connected to strain gauge for measurement of force output

C. Strain Gauge
1. one half anchored to machine; one half attached to movement arm of machine
2. measures changes in electrical resistance (ohms)
3. computer converts ohms to ft./lbs. (analog-to-digital conversion)

D. Potentiometer
1. device which indicates the position of the angle selector throughout the patient's ROM
2. one-half connected to machine; one-half connected to the angle selector

E. Handlebars
1. attached to movement arm; provide standardized positioning of upper extremities during testing and training
2. patient should maintain a loose, comfortable grip (thumb and forefinger) during set-up procedures, testing and training

E. Headrest
1. attached to movement arm; provides comfort, support and standardized positioning of the head
2. top of pad should be adjusted to the base of occipital bone
3. patient should not "arch" neck during testing and training

F. Angle Selector
1. locks movement arm into any 3°, from 72° to 0° of lumbar flexion
   a) handle in -- locks movement arm into even angles
   b) handle out -- locks movement arm into odd angles
   c) handle in neutral -- movement arm unlocked

H. Movement Arm Lock
1. changes mode of machine from isometric to dynamic, or dynamic to isometric
2. UP position = isometric; DOWN position = dynamic

(Lumbar Machine Parts)

I. Force/Angle Switch

1. when in testing mode, changes computer to indicate either angular position of movement arm, or force (torque) output
2. switch also performs other computer related functions
   a) logs in angle of top-dead-center
   b) logs in maximum angle of extension/flexion
   c) terminates dynamic exercise

J. Weightstack

1. stroke length = 6 in.
2. total of 400 “ft.” pounds; 800 “6 in.” pounds
   a) minimizes acceleration of weightload
   b) minimizes mechanical friction of machine

K. Variable Resistance Cam

1. designed to provide adequate muscle overload at all points throughout the lumbar extension ROM
2. varies the resistive torque (moment arm) from 72 to 0 deg. of lumbar extension on a ratio of 1. 4: 1

L. Pelvic Restraint

1. stabilization pads for lumbar/pelvic area
2. two round pads on their own axes of rotation
3. when pelvis is properly secured, pads should not rotate (pads and lumbar area act as a “gear”)
4. iliac crests should be at or above the axes of the pads

M. Thigh Restraint

1. adjustable crank, tightens and loosens thigh restraint

N. Femur Restraint

1. acts as fulcrum in redirecting restraining force from footboards down into the pelvic girdle
2. height of restraint is adjustable, with 6 hole settings
   a) most females = #3 or #4
   b) most males = #4 or #5
   c) for patients $\geq$ 6ft (long legs) or patients using auxiliary seat cushion, hole = #6
   d) knees should be placed in middle of pads, with front of restraints level with top of patellas

O. Footboard

1. serves as a platform for proper positioning of feet
   a) heels should be positioned at base of board
   b) toes should be pointed inward slightly

(Lumbar Machine Parts)

P. Footboard adjustment
1. adjustable crank system that pushes tibias into femurs, and femurs down into pelvic girdle
2. proper adjustment should allow 1/2 in. between heels and board when fully restrained

Q. Torso Mass Counterweight
1. 155 lb. weight counterbalances the mass of upper body to eliminate measurement errors due to gravity
   a) adds to measurement in flexed positions
   b) subtracts from measurement in extended position
2. must be leveled prior to being locked at top-dead-center

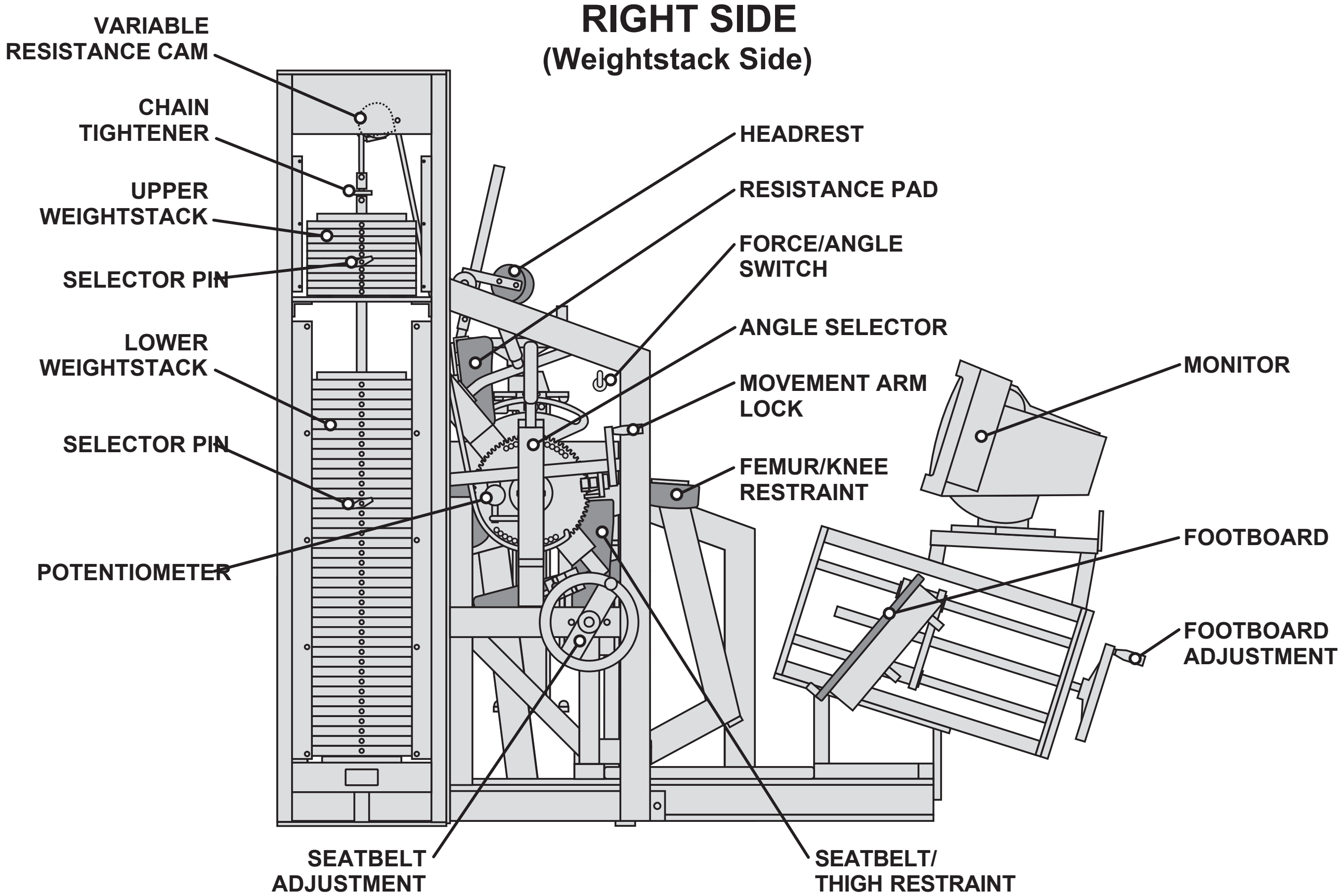
R. Torso Mass Counterweight Lock
1. locks CW to multi-position flange at top-dead-center position
2. should be unlocked during calibration and when locating top-dead-center position

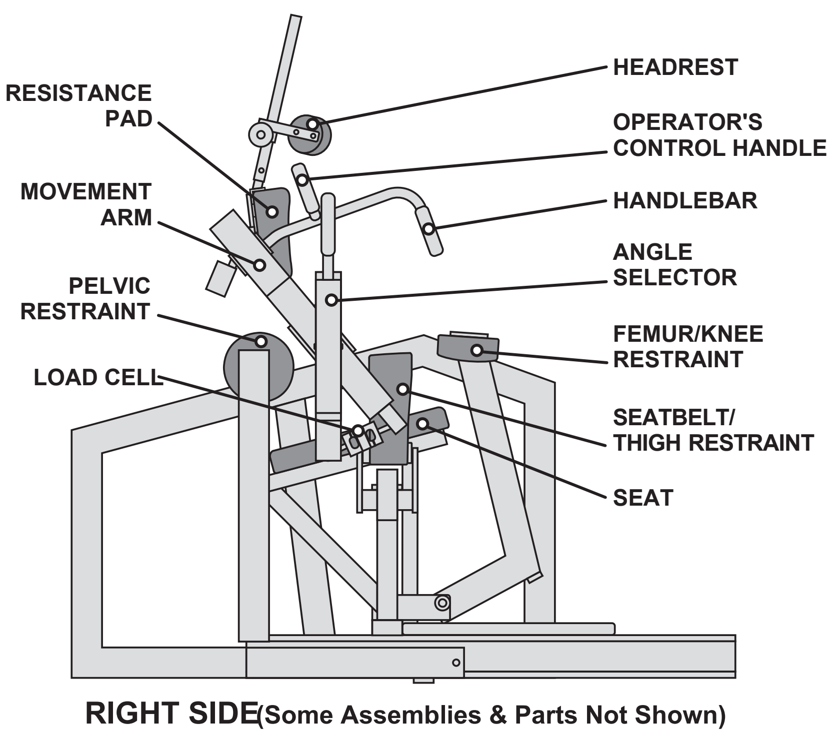
S. Torso Mass Counterweight Adjustment
1. adjustable crank, raises and lowers CW, thereby increasing or decreasing amount of torque on movement arm
   a) cranking clockwise (raising CW) decreases torque
   b) cranking counterclockwise (lowering CW) increases torque
2. digital counter, allows standardization of CW position

Lumbar Extension Machine

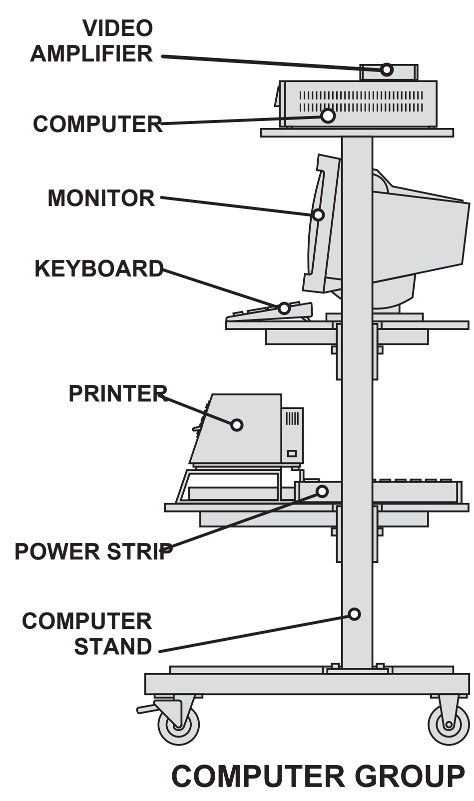
Figure 1

RIGHT SIDE
(Weightstack Side)





RIGHT SIDE (Some Assemblies & Parts Not Shown)

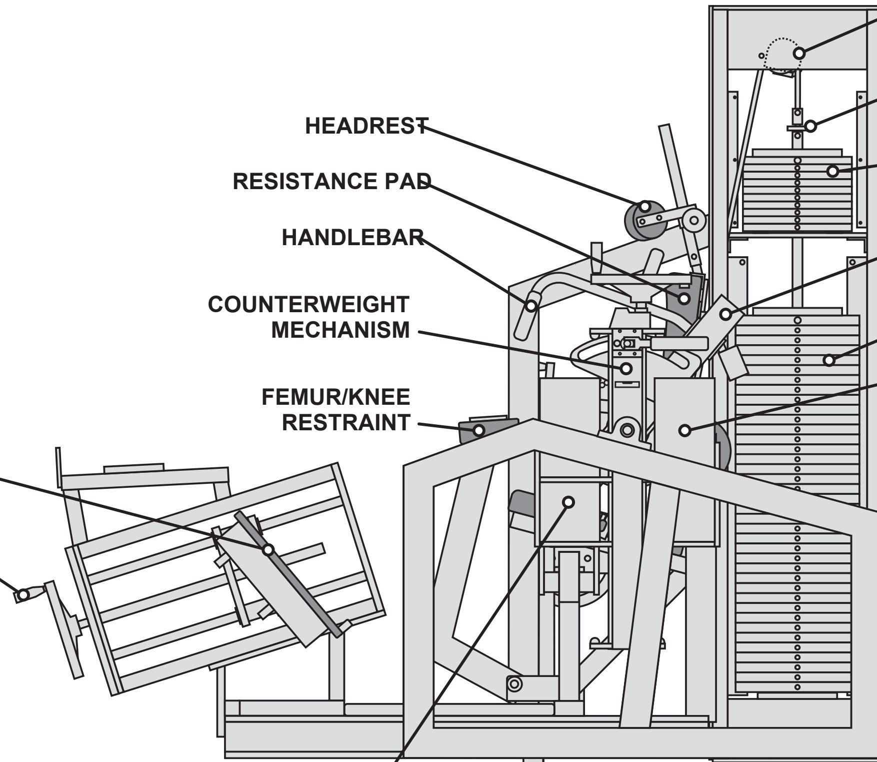


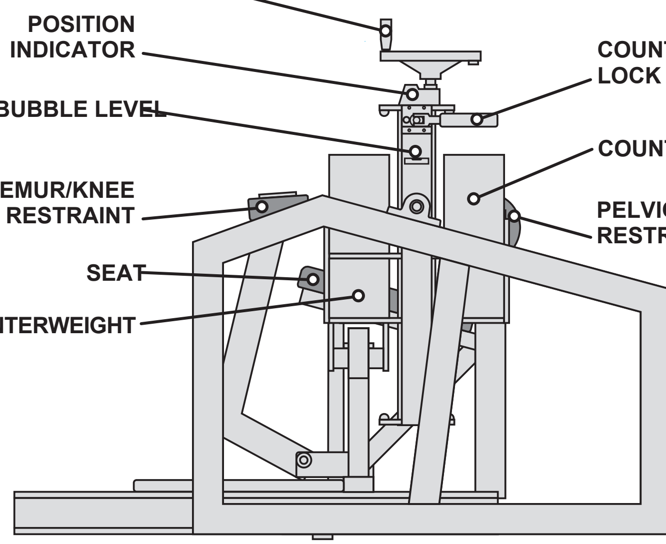
COMPUTER GROUP

Lumbar Extension Machine

Figure 2

LEFT SIDE
(Counterweight Side)



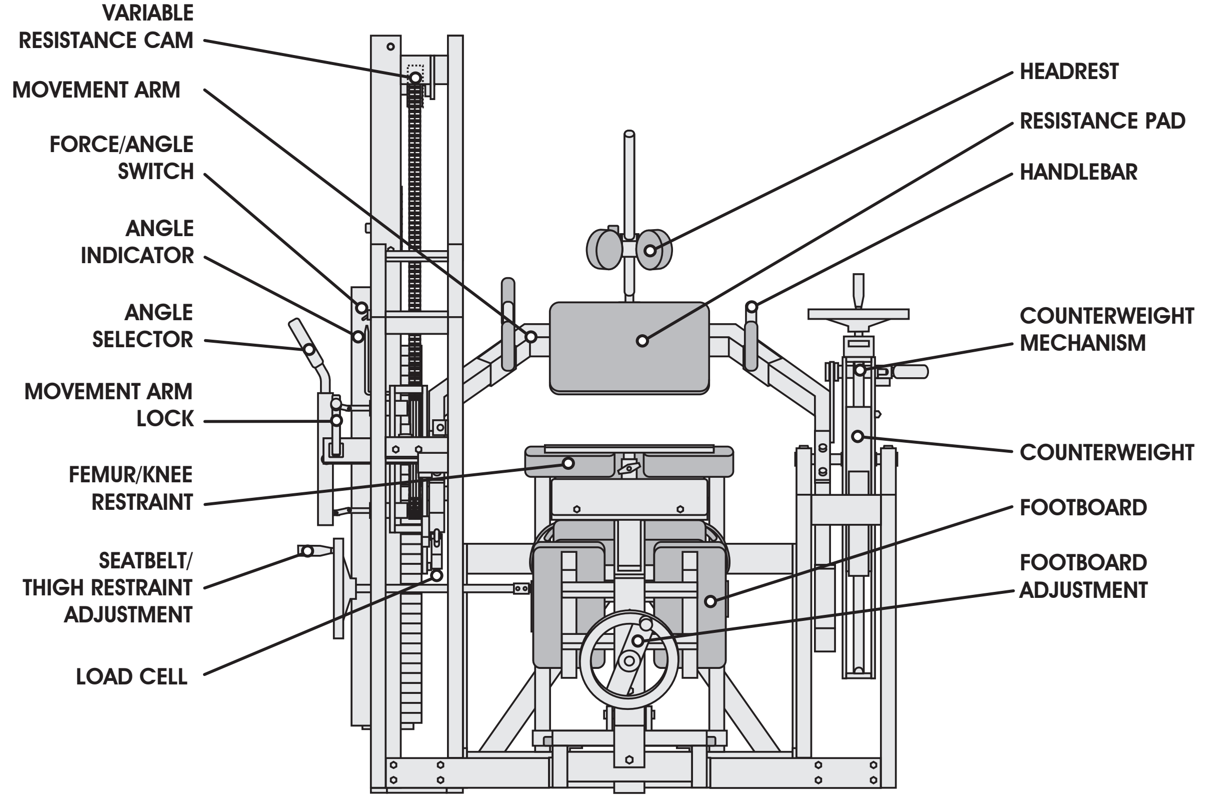


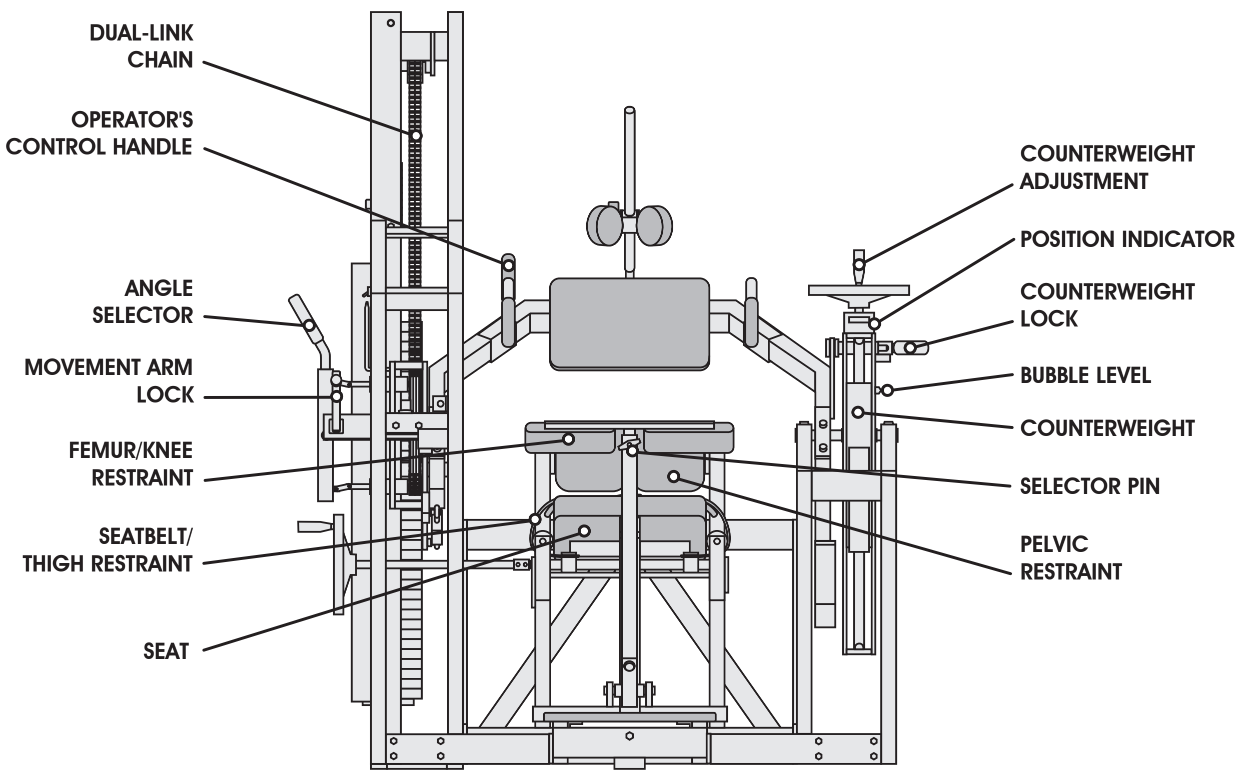
LEFT SIDE (Some Assemblies & Parts Not Shown)

Lumbar Extension Machine

Figure 3

FRONT





FRONT (Some Assemblies & Parts Not Shown)

Cervical Extension Machine Parts

A. Headpad
1. attached to movement arm, serves as the mechanism to which cervical extensor force is applied
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F. Movement Arm Lock
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2. UP position = isometric; DOWN position = dynamic

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1. when in testing mode, changes computer to indicate either angular position of movement arm, or force (torque) output
2. switch also performs other computer related functions
   a) logs in angle of top-dead-center
   b) logs in maximum angle of extension/flexion
   c) terminates dynamic exercise

H. Weightstack
1. stroke length = 1.5 in.
2. total of 75 “ft” pounds; 900 “1.5 in.” pounds
   a) minimizes acceleration of weightload
   b) minimizes mechanical friction of machine

(Cervical Machine Parts)

I. Chain Tightener
1. device which removes excess "slack" in the chain so that full ROM repetitions will be accurately counted
2. should be loosened during calibration and tightened during dynamic exercise

J. Variable Resistance Cam
1. designed to provide adequate muscle overload at all points throughout the cervical extension ROM
2. varies the resistive torque (moment arm) from 126° to 0° of cervical extension on a ratio of 1.4:1

K. Shoulder Harness
1. adjustable straps positioned over the shoulders which are used as part of the restraint system
2. assists in stabilizing the upper body during testing and training

L. Seat Belt
1. secured across the patient's waist
2. stabilizes lower body during testing and training

M. Torso Restraint
1. stabilizes upper body during testing and training
2. two rotating pads adjust to fit contour of upper body

N. Torso Restraint Adjustment
1. adjustable crank tightens and loosens torso restraint

O. Seat Height Adjustment
1. adjustable crank, raises and lowers seat position
2. digital counter allows for standardized positioning of patient

P. Head Mass Counterweight
1. counterbalances the mass of the head to eliminate measurement errors due to gravity
   a) adds to measurement in flexed positions
   b) subtracts from measurement in extended positions
2. must be leveled prior to being locked at top-dead-center

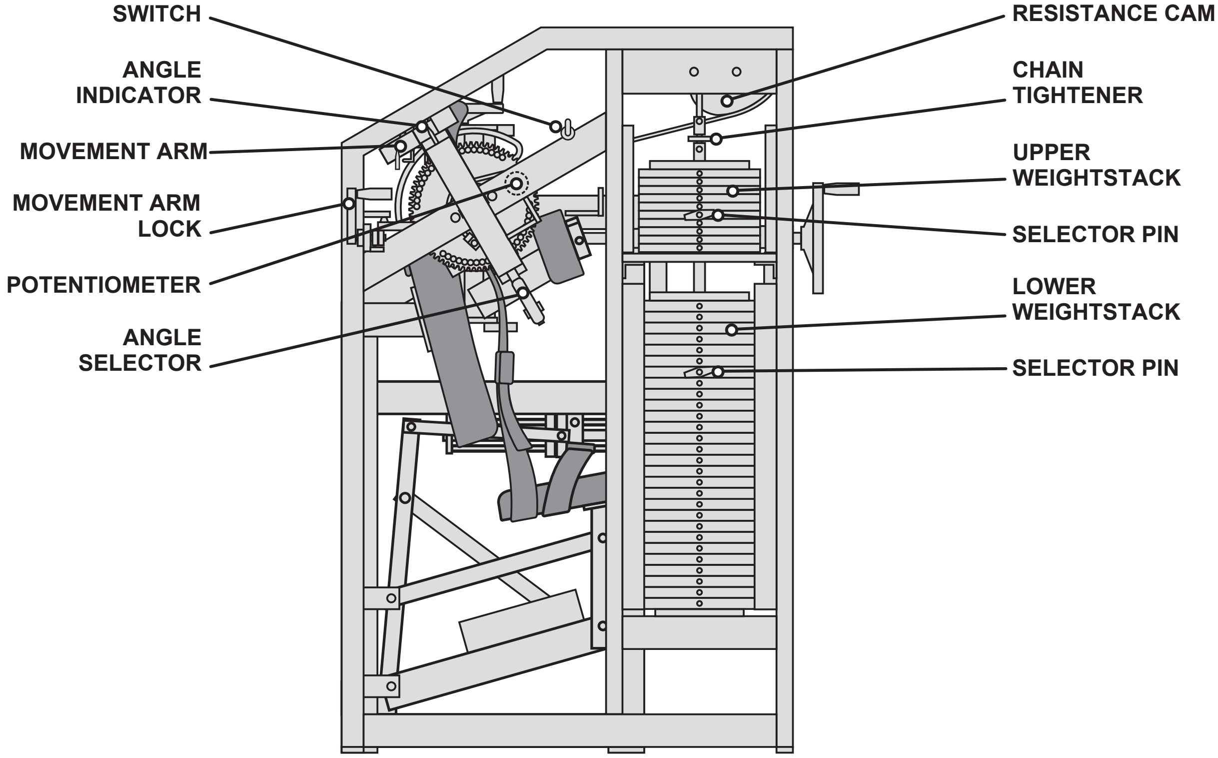
Q. Head Mass Counterweight Lock
1. locks CW to multi-position flange at top-dead-center position
2. should be unlocked during calibration and when locating top-dead-center position

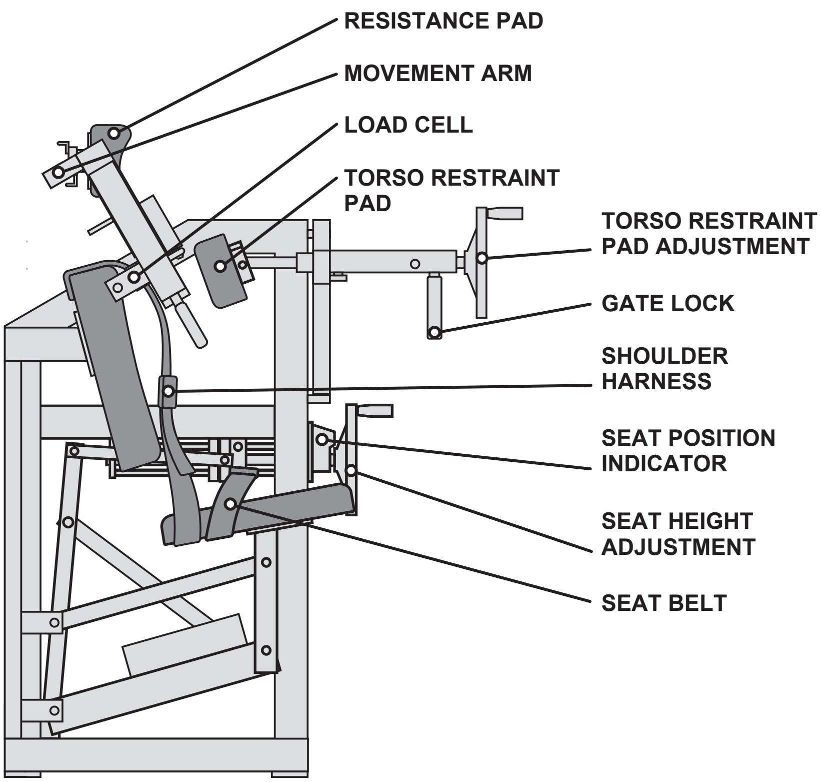
R. Head Mass Counterweight Adjustment
1. adjustable crank, raises and lowers CW, thereby increasing or decreasing amount of torque on movement arm
   a) cranking clockwise (raising CW) decreases torque
   b) cranking counterclockwise (lowering CW) increases torque
2. number line ruler, allows standardization of CW position

Cervical Extension Machine

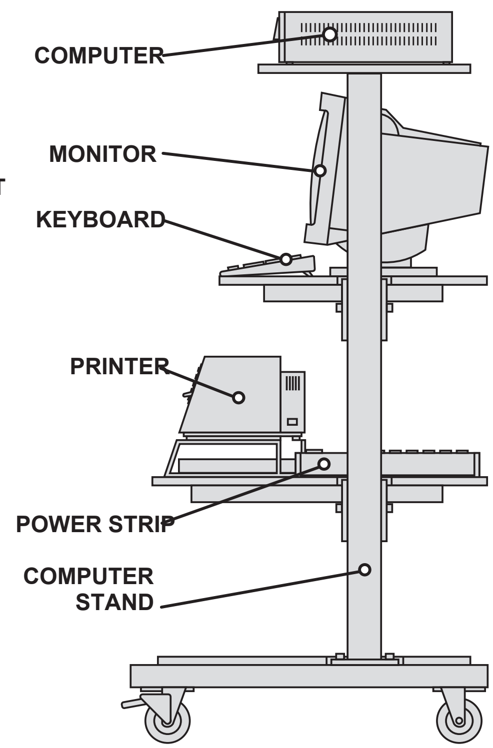
Figure 1

RIGHT SIDE





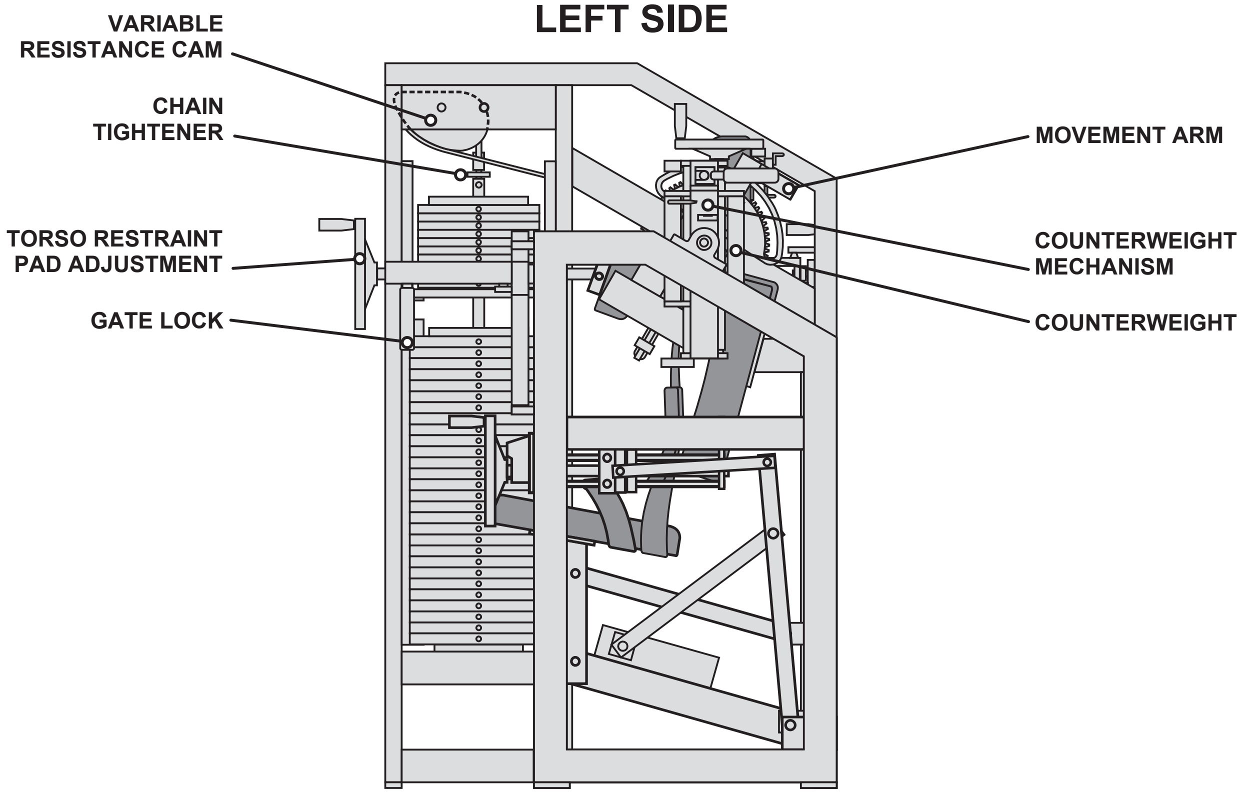
RIGHT SIDE (Some Assemblies & Parts Not Shown)

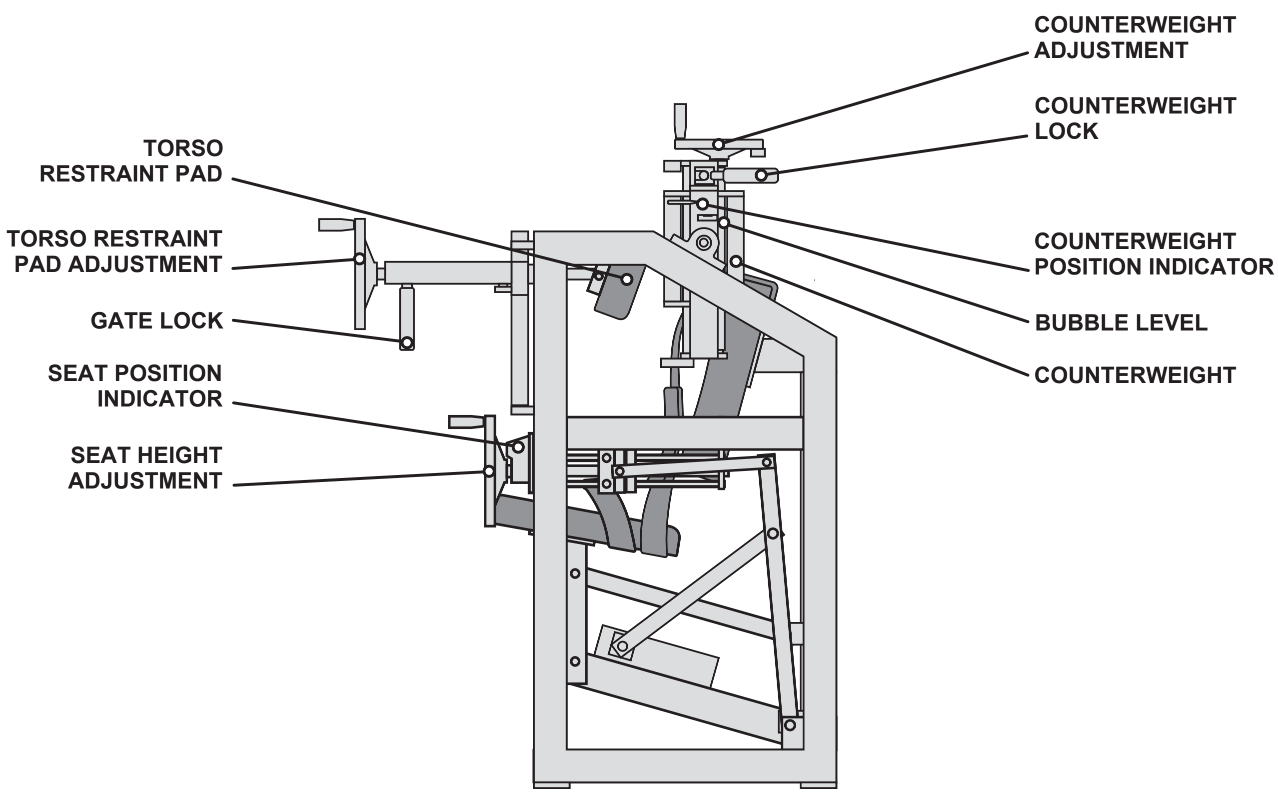


COMPUTER GROUP

Cervical Extension Machine

Figure 2



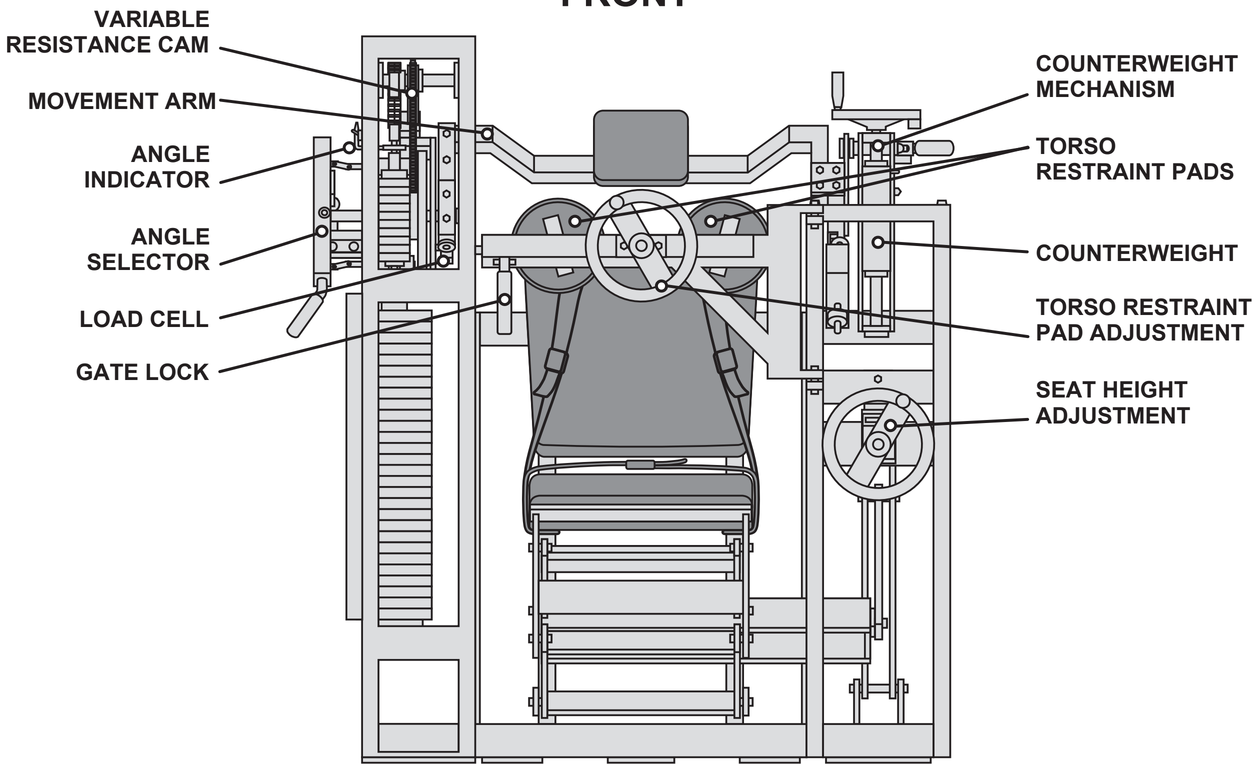


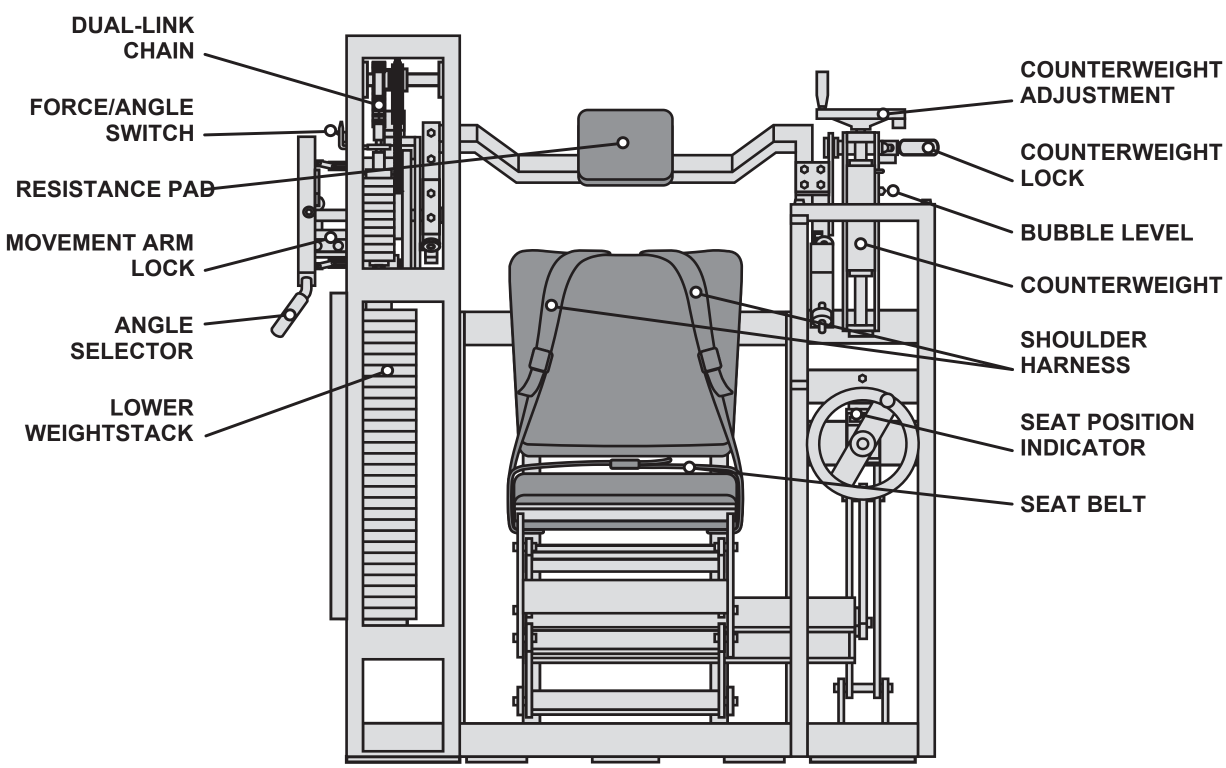
LEFT SIDE (Some Assemblies & Parts Not Shown)

Cervical Extension Machine

Figure 3

FRONT





FRONT (Some Assemblies & Parts Not Shown)

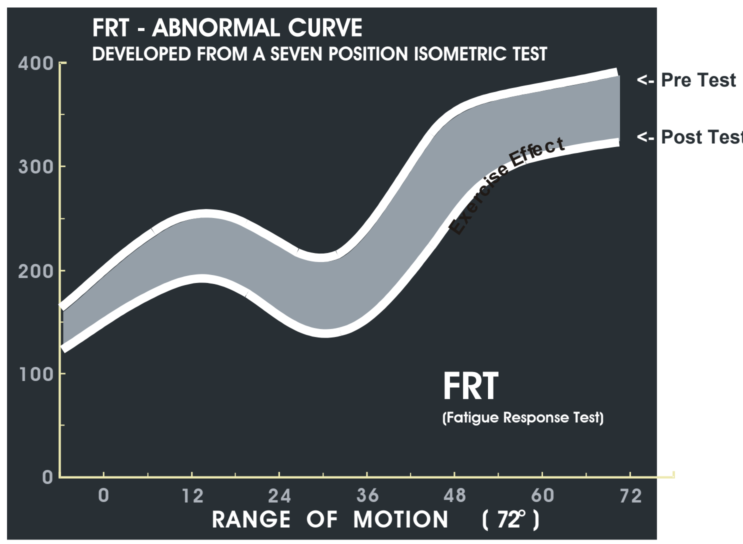
Clinical Fatigue Response Testing

Purpose

The Fatigue Response Test (FRT) is a 3-part test procedure designed to measure the endurance characteristics of a specific muscle group. Information obtained from the FRT can be used to further delineate an exercise prescription based upon the patient's amount of fatigue consequent to the test. It is recommended that the FRT be administered clinically under the following conditions:

1) The patient is not limited by joint pain when performing dynamic exercise
2) The patient is able to exercise to volitional muscular fatigue
3) The patient has demonstrated reliable efforts with previous isometric testing
4) The patient has not responded to the recommended standard protocol

Two tests of functional strength. The top of the shaded area shows the level of fresh strength, while the bottom shows remaining strength after the subject was exercised. The shaded area between the two curves is fatigue from the exercise. The dips in the midrange of movement indicate abnormal function. The fact that the same abnormal shape was produced during both tests indicates valid test results.



Procedure

To perform the FRT, a patient is seated and restrained in the MedX machine in order to isolate the target muscle group. The patient then performs a series of maximal effort isometric contractions at multiple joint angles through a pain-free ROM (Pre FRT). After a brief rest, the patient performs as many dynamic variable resistance repetitions as possible using a weightload equal to 50% (lumbar extension) or 80% (cervical extension) of the peak torque from the Pre FRT. Each repetition should be performed through the full painfree ROM in a slow, controlled manner. The patient should perform the concentric portion of the repetition for 2 seconds, pause at full contraction for 1 second, then complete the eccentric portion over a 4 second period (total 7 seconds per repetition). Repetitions should be performed until the patient is unable to move the weightload through a full ROM (volitional fatigue). Immediately following the dynamic repetitions (within 1 minute) the patient performs maximal effort isometric contractions at the same joint angles selected for the Pre FRT (Post FRT). The patient is then released from the machine.

Interpretation

The difference between the Pre FRT and Post FRT isometric tests represents the fatiguing effect of the dynamic exercise. The amount of fatigue (inroad) will vary among individuals, and is indicative of the fiber type characteristics of the lumbar extensor musculature. For example, an inroad $\geq$ 30% reflects fatigue characteristics of fast twitch muscle fibers, which have a low tolerance to exercise (poor endurance). An inroad $\leq$ 10% reflects fatigue characteristics of slow twitch muscle fibers, which have a high tolerance to

Clinical Fatigue Response Testing (cont.)

exercise (high endurance). An inroad between 10% and 30% reflects fatigue characteristics of an unknown mixture of fast and slow twitch muscle fibers, with a moderate tolerance to exercise (moderate endurance).

Exercise Prescription

When a motivated individual fails to demonstrate progress (progressive increase in isometric strength, progressive increase in dynamic weightloads) using the standard treatment protocol, his/her exercise prescription may need to be altered based upon the findings from the FRT. Use the following table as a guide:

Percent Fatigue from FRT	Muscle Group	Time Under Load	Repetition Range	Exercise Frequency
≤ 10%	Lumbar/Cervical	105 – 140s	15 - 20	2X/WK
≥ 30%	Lumbar	56 - 84s	8 - 12	1X/WK
	Cervical	70 - 105s	10 - 15	1X/WK

Spinal Anatomy

Overview

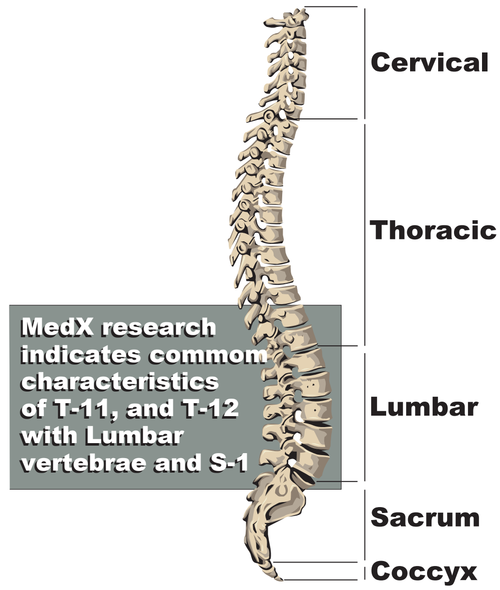
Neck and back pain, especially pain in the lower back, is one of the most common health problems in adults. Fortunately, most back and neck pain is temporary, resulting from short-term stress on the muscles or ligaments that support the spine rather than from a serious injury or medical condition such as nerve damage or kidney disease.

Anatomy

The back is an intricate structure of bones, ligaments, muscles, nerves, and tendons. The backbone, or spine, is made up of 31 bony segments called vertebrae:

8 cervical (neck) vertebrae
12 thoracic (middle back) vertebrae
5 lumbar (lower back) vertebrae*
5 sacral (lowest area of the back) vertebrae
1 coccygeal (coccyx, or tailbone) vertebra
(made up of several fused segments)

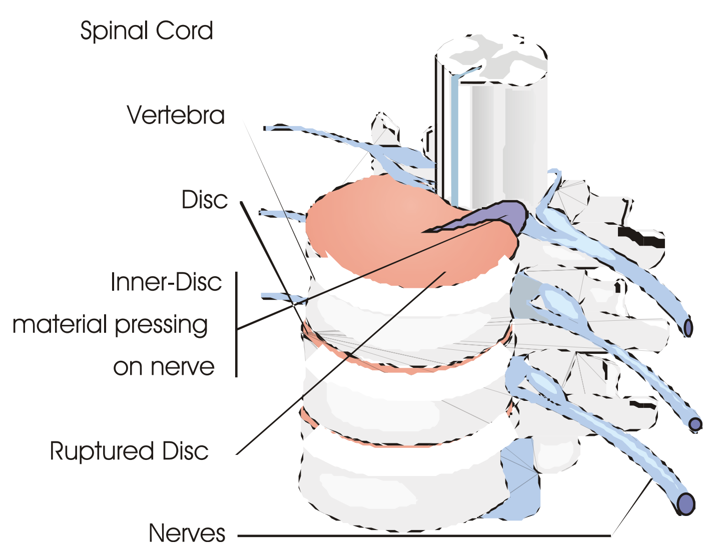
* MedX research contends that the lumbar region really starts at T-11, based upon the attributes of the vertebra.



The vertebrae are arranged in a long vertical column and held together by ligaments, which are attached to muscles by tendons. Between each vertebra lies a gel-like cushion called an intervertebral disc, consisting of semifluid matter (called nucleus pulposus) that is surrounded by a capsule of elastic fibers (called annulus fibrosus).

The spinal cord is an extension of the brain that runs through a long, hollow canal in the column of vertebrae. The meninges , cerebrospinal fluid, fat, and a network of veins and arteries surround, nourish, and protect the spinal cord.

Thirty-one pairs of nerve roots emerge from the spinal cord through spaces in each vertebra. The spinal cord and peripheral nerves perform essential sensory and motor activities of the body. The peripheral nervous system conveys sensory information from the body to the brain and conveys motor signals from the brain to the body.

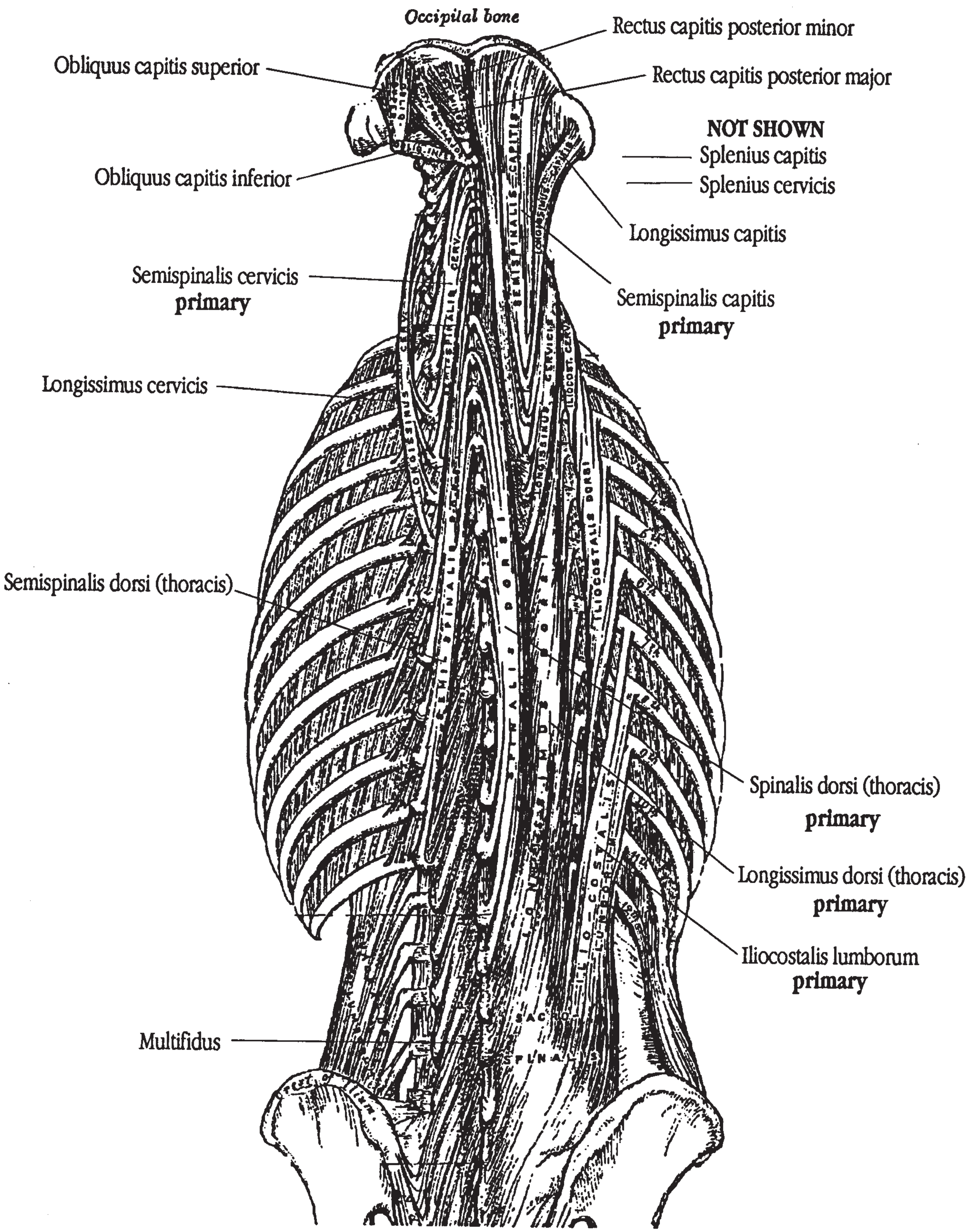


Incidence and Prevalence

In the United States, back pain is reported to occur at least once in 85% of adults below the age of 50. Nearly all of them will have at least one recurrence. It is the second most common illness-related reason given for a missed workday and the most common cause of disability. Work-related back injury is the number one occupational hazard.

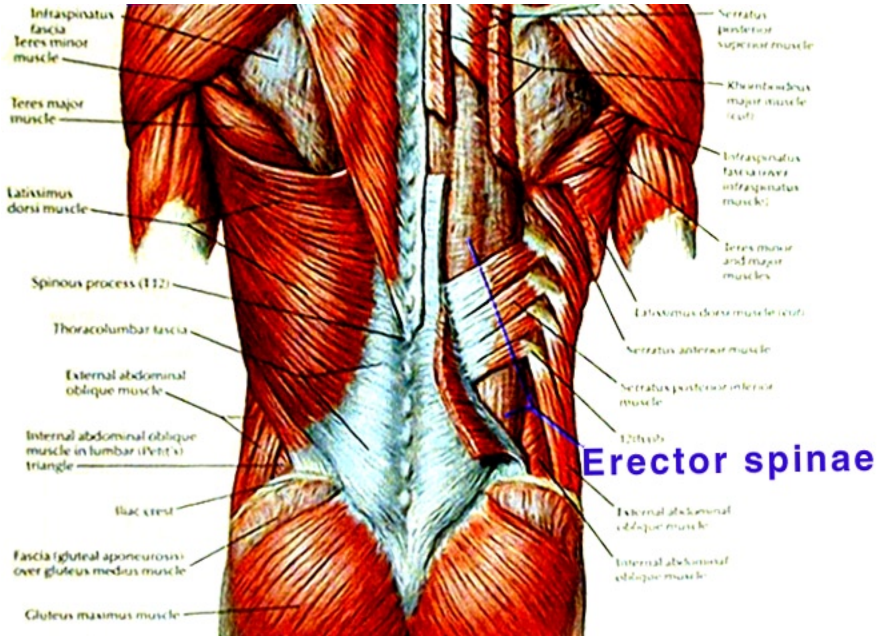
Following iryury, healing occurs in three stages; inflammation, repair and remodeling.

Cervical and Lumbar Musculature



Posterior View

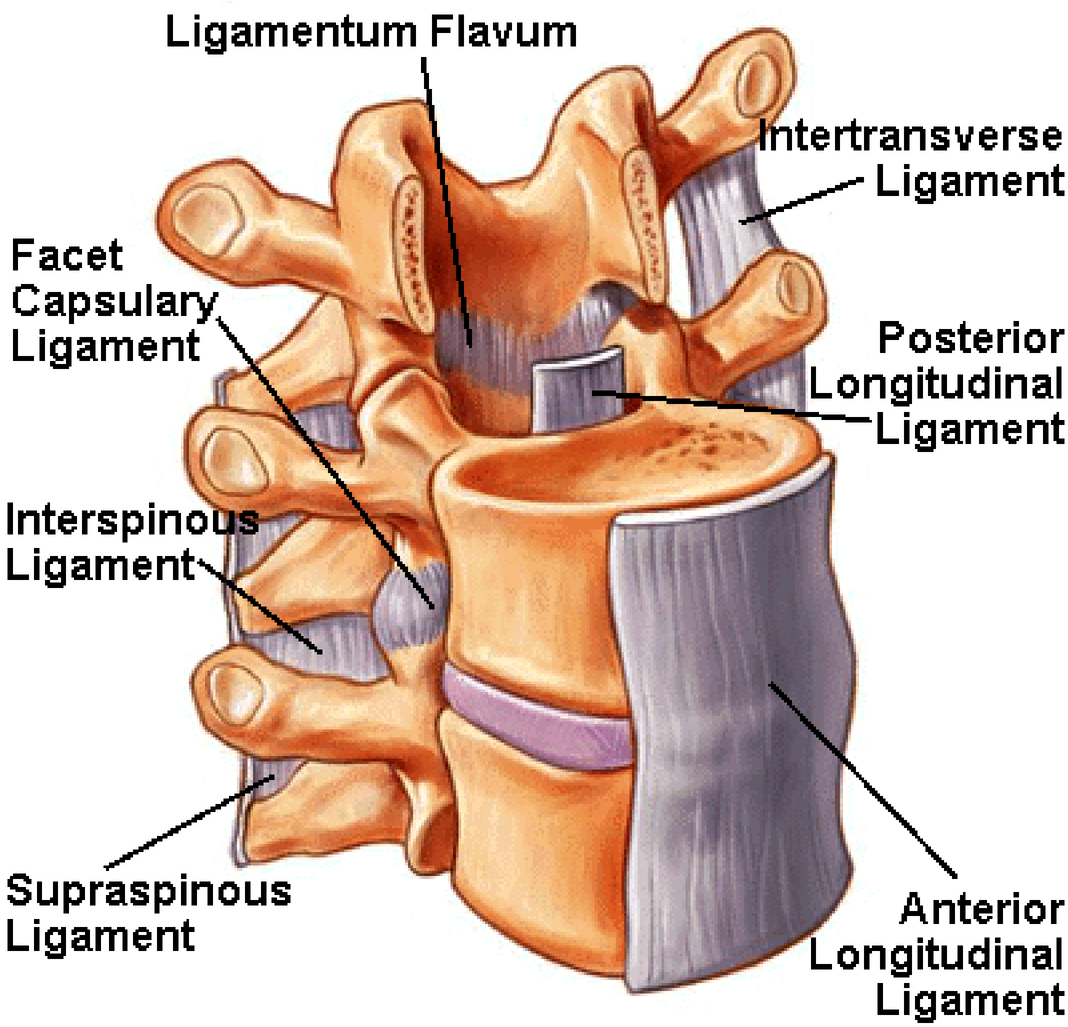
Structural Inegrity of the Lumbar Spine



While the upper part of the spine, above T 10 through T 1, is supported by the closed ribcage, the lower spine is supported primarily by the muscles, the tendons and the ligaments in that area. Weakness in any of these support structures can lead to injury.

Soft tissue iryury results from failure of collagen fibers, and the type of injury can be either microtrauma resulting from overuse, and macrotrauma resulting from the imposition of a force that exceeds the structural strength of the tissues. A higher level of structural strength can withstand a higher level of force.

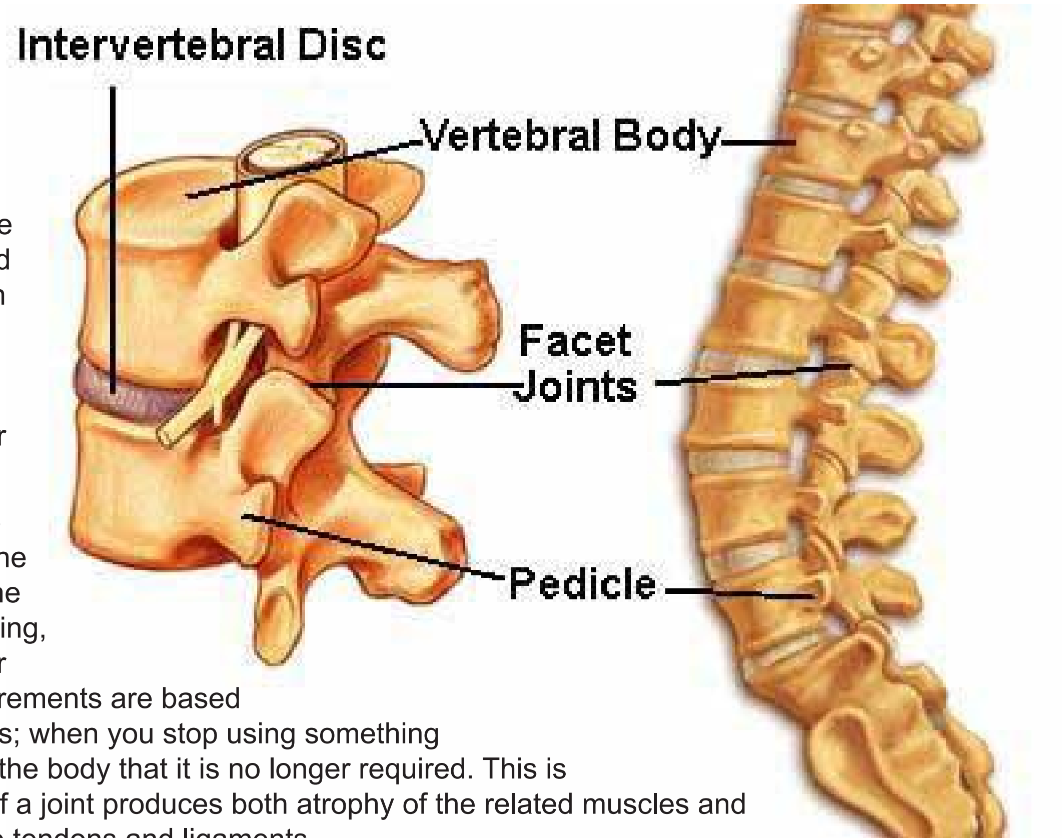
Structural strength can be determined through its correlation to *functional* strength, and MedX medical machine testing can accurately measure functional strength. Exercise increases the size and strength of the muscles, tendons, ligaments and bones; thus increasing structural strength and reducing chance of injury.



The spine is designed to permit bending and twisting, but is also intended to prevent bending or twisting beyond a degree that would become dangerous. In some ways the spine is similar to a tall, thin tower whose resistance against horizontal force is provided by cables attached to the tower and anchored in the ground. The muscles, tendons, and the ligaments support the spine in a similar way. But unlike the

Structural Integrity of the Spine (cont.)

cables supporting a tower, the spinal support structures resist both pulling and compression forces. The bones and discs of the spine are primarily intended to resist compression forces, and provide very little in the way of resistance against forces from any other direction.



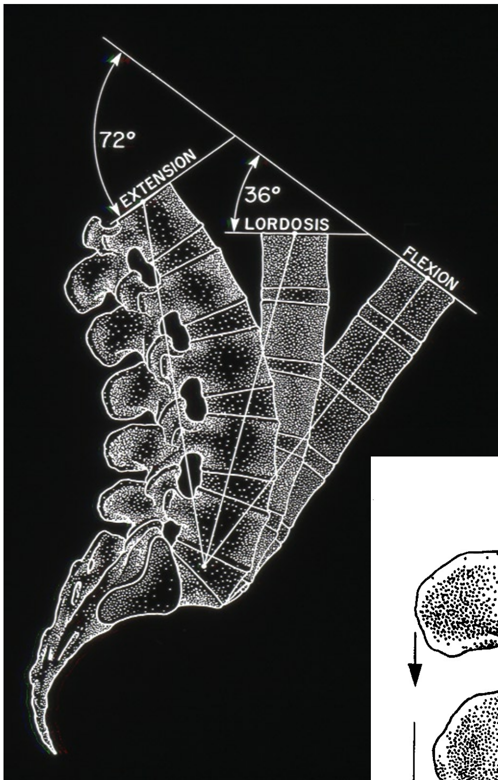
Just as with all of the tissues in the body, the soft tissue of the spine are constantly changing, becoming stronger or weaker. Future requirements are based upon recent demands; when you stop using something you send a signal to the body that it is no longer required. This is why immobilization of a joint produces both atrophy of the related muscles and tissue changes in the tendons and ligaments.

But when you use these tissues at a level that is close to the momentary limit of functional ability, as an adaptive organism the body improves physiologically to meet the demands imposed upon it. Proper exercise stimulates these positive adaptations.

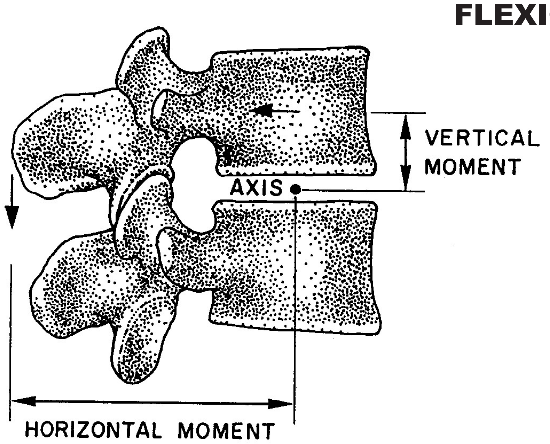
Proper exercise is important for every voluntary muscle in the body, but even more critical for the muscles of the spine. Large-scale tests involving many thousands of individuals at the University of Florida produced a surprising picture: most of us - including highly trained athletes - have weak lumbar extensors. However, even more amazing was the level of this weakness. By exercising these muscles on MedX equipment, it was possible to increase strength by several hundred percent!

According to leading orthopaedic specialists, some 80% of all back problems are the result of weak back muscles, or to be more precise, a weakness in the lumbar extensors. On the basis of these findings, scientists at the University of Florida developed a therapy that produced spectacular results in patients with chronic back problems. That system is based upon MedX patented technology.

Understanding Mechanical Advantage



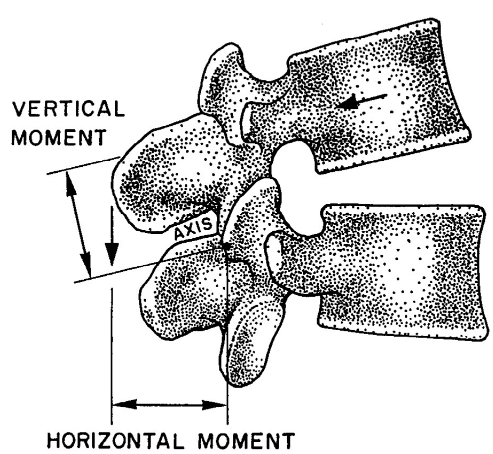
FLEXION



These drawings indicate the mechanical advantage in the flexed position — meaning that less force is needed to generate torque due to the leverage of the joint system. In extension, the axis of rotation shifts from between the vertebral bodies to rear of the posterior face of the lumbar vertebrae, essentially in the facets.

By using lateral X-ray pictures in the flexed and extended poisitions, it is possible to determine the angular relationships of the lumbar vertebrae as the spine moves from flexion (artistic rendering above) to extension (artistic rendering below).

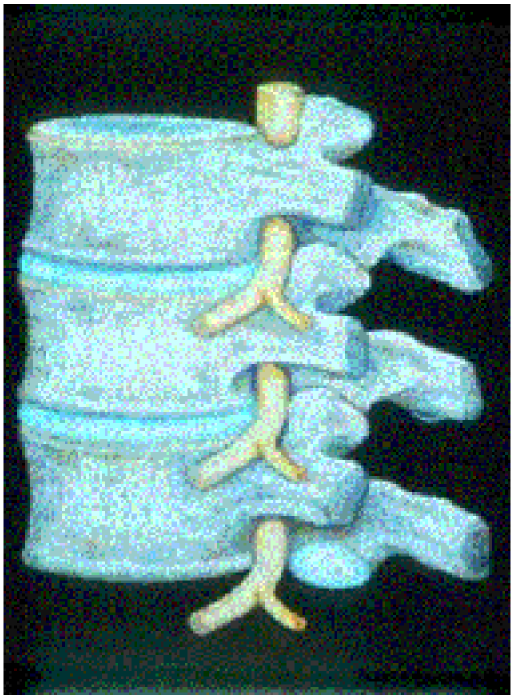
EXTENSION

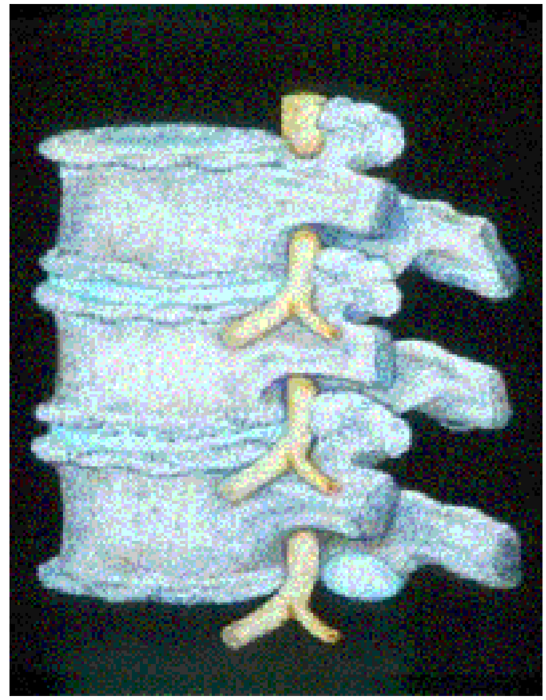


Disc Disease

Left lower photo depicts segemnts of the spine: vertebral body, intervertebral disc, articular facet, and intervertebral foramen with nerve root.

Right photo shows results of process that began with herniation of the intervertebral disc, associated ligament laxity and entrapment of the nerve root. A loss of disc space then occurs with further ligament laxity. Eventually, facet joint arthritis leads to bony overgrowth and stenosis of the intervertebral formen. MedX not only strengthens spinal muscles, but hydrates the discs also.





Safeguarding the Cervical

Head and neck pain are common and costly concerns that plague a vast number of individuals in modern society. Neck pain often originates from muscular weakness and fatigue, and from injuries associated with accidents and participation in athletics. Neck injuries are especially prevalent in high impact activities such as football, wrestling, diving, and gymnastics. Cervical spine injuries are caused by contact, overuse, twisting, compression, direct shearing forces, and alignment abnormalities.

Neck muscle strength has been shown to be a controlling factor in the stability of the cervical spine. The importance of strengthening the neck musculature to reduce the risk of injury, alleviate neck pain, and in rehabilitation has been well documented, particularly in research using the MedX Cervical Extension Machine.

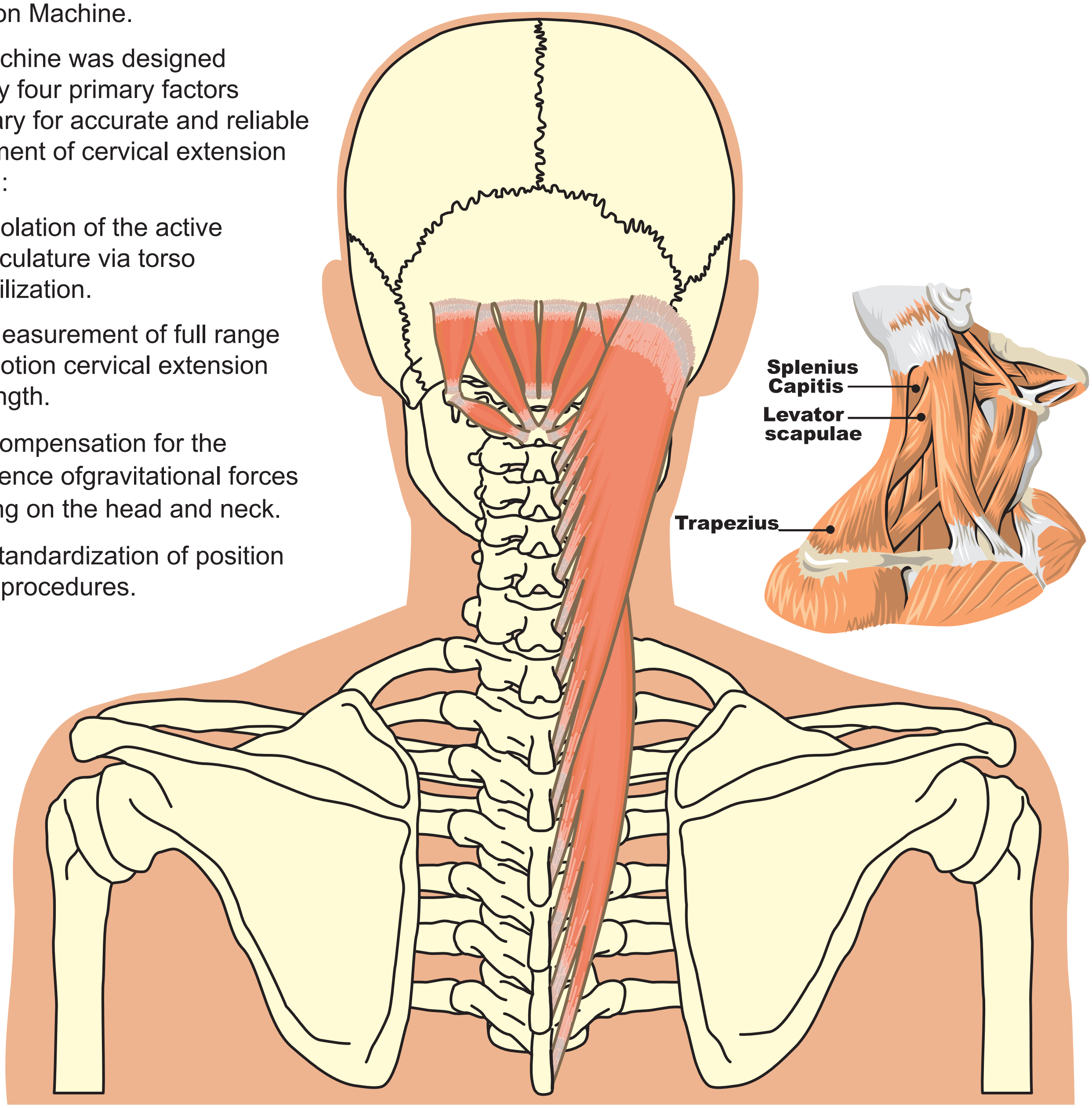
This machine was designed to satisfy four primary factors necessary for accurate and reliable assessment of cervical extension strength:

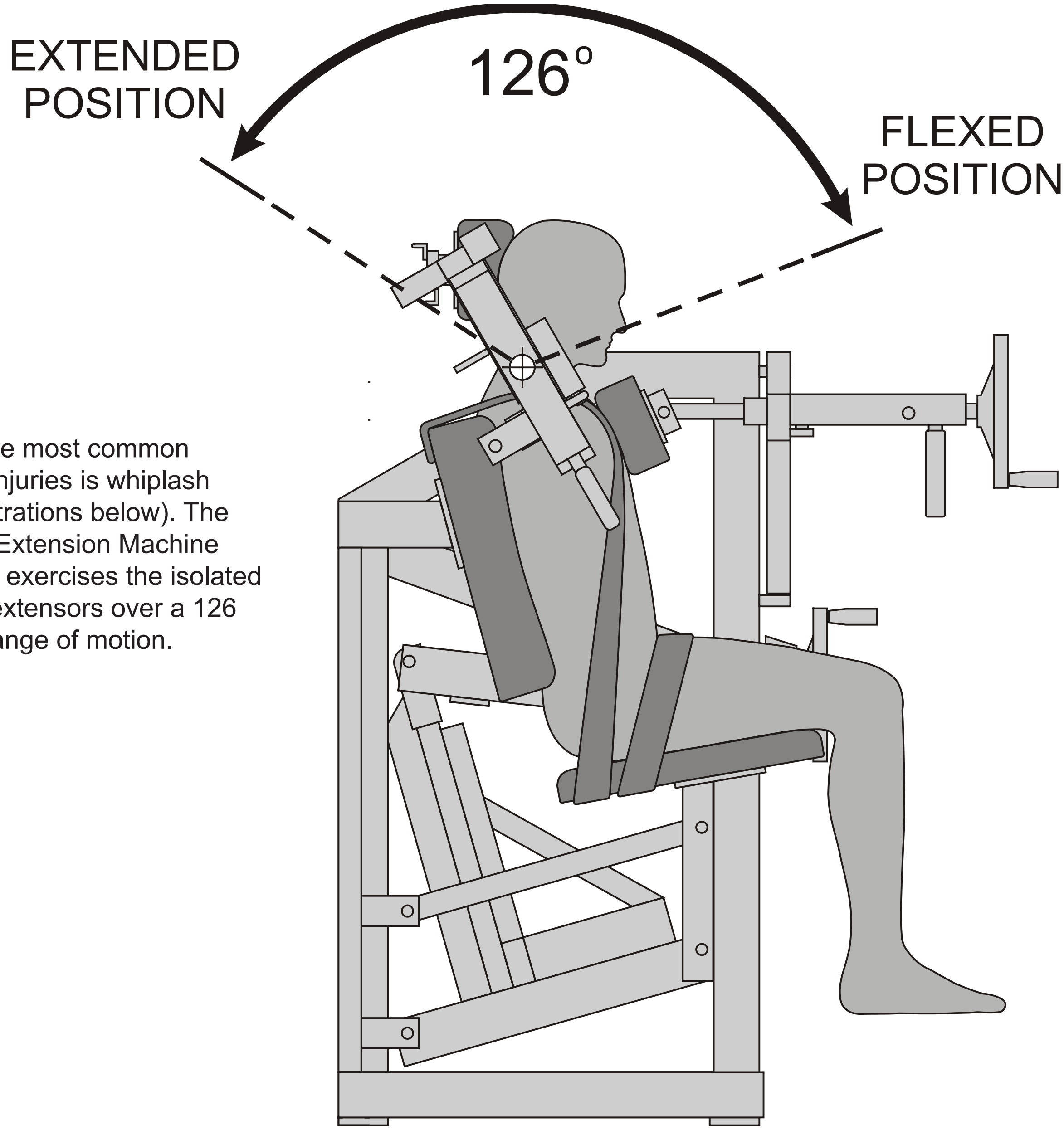
1) Isolation of the active musculature via torso stabilization.

2) Measurement of full range of motion cervical extension strength.

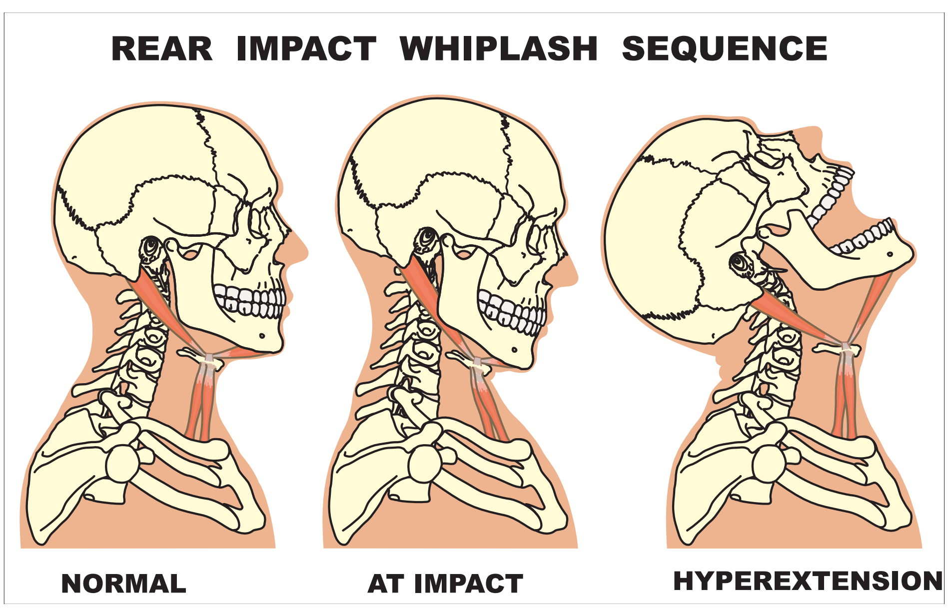
3) Compensation for the influence ofgravitational forces acting on the head and neck.

4) Standardization of position and procedures.





One of the most common cervical injuries is whiplash (see illustrations below). The Cervical Extension Machine tests and exercises the isolated cervical extensors over a 126 degree range of motion.



Strength Curve Analysis

The purpose of this section is to assist clinicians in learning how to interpret test results obtained using MedX evaluation and rehabilitation equipment. The evaluation of strength curves is necessary for health care professionals who wish to use MedX machines as part of their rehabilitation programs. The information that is presented in a patient's strength curve(s) can be used for many purposes, eg. normative comparisons, exercise prescription, confirmation of abnormalities, marking progress, etc. Furthermore, it is often necessary to present this information to patients, lawyers, rehabilitation specialists, insurance adjustors, etc. in a clear, concise manner.

General Considerations

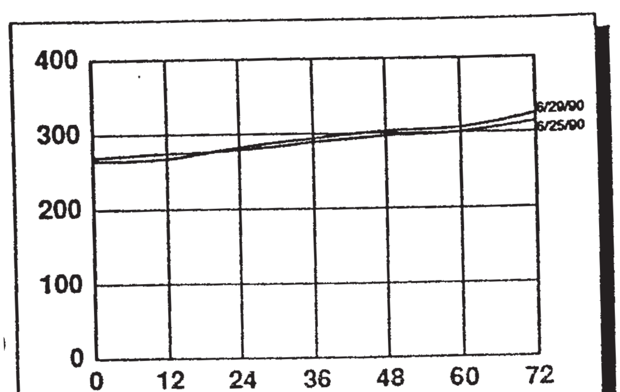
There are at least three basic considerations to keep in mind when evaluating patient strength curves:

1) Be reasonable in your expectations. Realize that you will be dealing with patients whose efforts may vary depending upon their pathology, motivation, mood, etc. You can't expect perfect test results all of the time.
2) You need to have more than one strength curve in order to make objective evaluations concerning test reliability and validity.
3) Look at all of the Information that is presented to you, including; dates, times, torque values, remarks, shape of the curves, 24 hr. history, etc., in order to make a comprehensive and meaningful interpretation.

I. Establish Reliability

The initial step in interpreting strength curves is to determine whether or not the patient has produced valid test results. Without an accurate and reliable test, there is no basis for determining the characteristics of a strength curve or evaluating the effects of a rehabilitation program. To establish reliability, the clinician should compare two or more strength curves obtained from the patient. There are three types of comparisons that can be made: 1) Short-term comparisons, 2) Long-term comparisons, and 3) Comparisons between strength curves obtained during a Fatigue Response Test. The criteria for establishing reliability vary depending upon the type of comparison:

1. Short-term Comparisons
This involves the comparison of two or more maximal isometric strength tests separated by a relatively short time span (from72 hours to 2 weeks). When comparing short-term measurements of strength, the following criteria should be used to establish reliability:



Short-term Isometric Test Comparison

a. Shape of the Strength Curve — The shape (slope) of the curves should be similar. If abnormalities in the shape of the curve are present, they should repeat from one test to another at the same angles within the ROM.

b. Torque Values — In addition to the shape of the curves, the torque values at each angle of measurement should also be similar. However, a patient's strength may vary from one day to another. The acceptable allowance for strength variation from test to test is approxirnately: ±10-20% at each angle of measurement. For example, if a torque value of 200 ft-lb was obtained at a given angle during Test 1, the torque value from Test 2 should fall between 160 and 240 ft-lb for that same measurement angle. If the variation in torque is greater than ±20% at more than two angles of measurement, the strength curve should be considered unreliable. In this situation, additional strength curves should be obtained from the patient until reliability is established.

NOTE: Healthy, asymptomatic subjects are known to demonstrate a ±10-I5% variation in strength in short-term test-retest situations. Based upon clinical observations, we recommend increasing this value by 5% for the patient population (i.e. ±20%).

2. Long-term Comparisons

This involves the comparison of two or more maximal isometric strength tests separated by a substantial time span (4,8, 12, 2O weeks, etc.). Typically, long-term measurements of strength are analyzed to determine the effects of a treatment program. When interpreting long-term measurements of strength, one criterion should be used to establish reliability:

a. Shape of the Curves — If the patient demonstrates a relatively normal strength curve at the beginning of a rehabilitation program, post-treatment strength curves should also be similar in shape. However, if the patient demonstrates an abnormal strength curve at the beginning of a rehabilitation program, allowances should be made for the correction of strength deficiencies at specific joint angles over time, and for a flattening of the strength curve as treatment progresses (effect of cam). If significant changes in the shape of the patient's strength curve occur, it is recommended that another isometric test be administered within several days to establish reliability. In this case, the clinician can then use the reliability criteria for short-term comparisons of strength. For example, if the shape of a patient's 12-week strength curve had changed dramatically from baseline measurements, the clinician should test the patient again at 13 weeks. The strength curves for weeks 12 and 13 can then be compared with the shape or the strength curves and force values in mind.

3. Fatigue Response Test Comparison

This involves the interpretation of a fatigue response test (FRT) in which a measurement of maximal isometric strength is compared with a measurement of maximal isometric strength performed immediately following a set of dynamic repetitions performed to volitional muscular fatigue. In order to establish the reliability of this test sequence, one criterion should be used:

a. Shape of the curves — The two strength curves should be similar in slope and appear parallel. There should be a consistent amount of fatigue throughout the entire ROM. On occasion, a patient will fail to generate reliable test results at one or more angles of measurement. In this circumstance, the measured fatigue at the unreliable angle(s) will be different than that demonstrated throughout the rest of the ROM.

II. Compare the Strength Curve to Normal

Comparing a patient's strength curve to established norms is important in order to identify functional deficits and to evaluate the effectiveness of a treatment program. Variables to consider when comparing a curve to the 'norm' include:

1. Range-of-Motion — In general, healthy, untrained subjects demonstrate a full ROM of 72° on the lumbar extension machine; 126° on the cervical extension machine. Since factors other than pathology may affect joint flexibility (i.e., distribution of body fat), ROM should not be considered 'normal' or 'abnormal'. The terminology we recommend using to describe a patient's ROM is either 'full' or 'limited'.

2. Shape of the Curve — The shape of the strength curve for a healthy, untrained subject is linear and descending from flexion to extension. An abnormality will be visibly noted as a peak or trough.

3. Strength Values — A patient's absolute and relative (torque/bodyweight) strength values should be compared to age and gender-specific normative values obtained from healthy, untrained individuals.

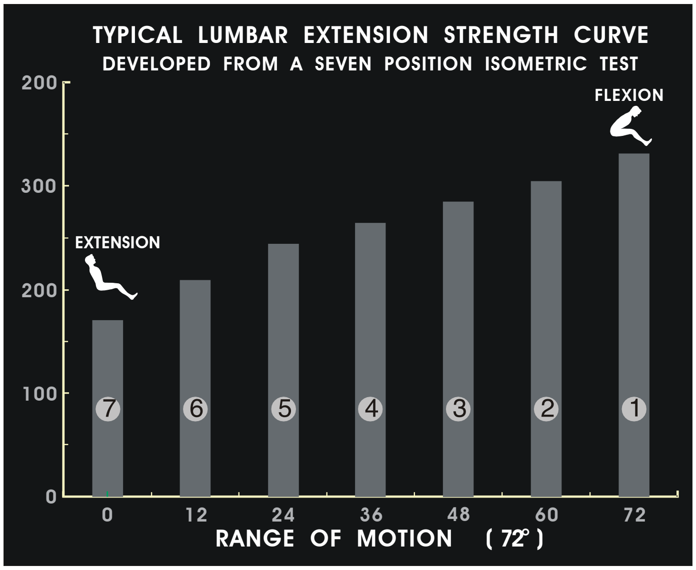
4. Flexion:Extenslon Strength Ratio — The flexion:extension ratio expresses strength in the fully flexed position relative to strength in the fully extended position. For example, a patient who has produced 250 ft.-lbs. of torque at 72° of lumbar flexion, and 100 ft.-lbs. at 0º, would have a flexion:extension ratio of 2,5:1 (250÷100). This means that the patient is 25 times stronger in their fully flexed position than in their fully extended position. Flexion:extension ratios for healthy, untrained males and females are presented in Table 1.

TALBE 1: Average Male and Female Strength Values

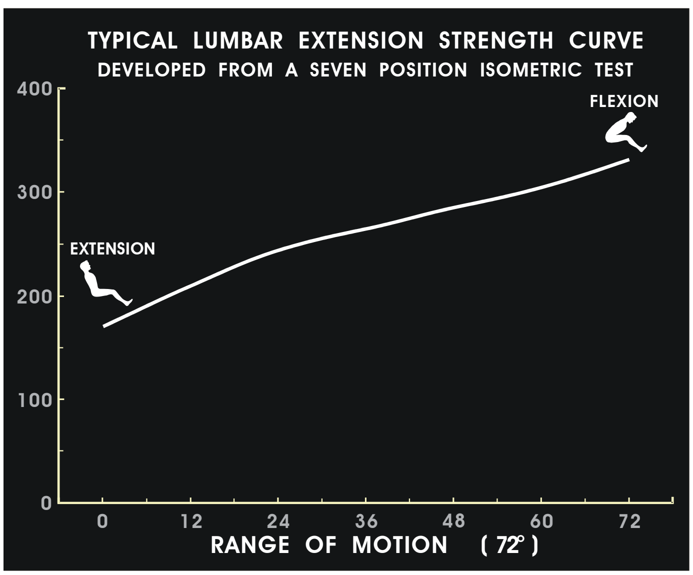
Movement	Gender	Age	Flexion:Extension Ratio
Lumbar Extension	Male	18-35 yr	2.0:1
		36-59 yr	2.3:1
		60-78 yr	2.1:1
	Female	18-35 yr	1.9:1
		36-59 yr	1.9:1
		60-78 yr	1.9:1
Cervical Extension	Male	18-60 yr	1.6:1
	Female	18-60 yr	1.3:1

*Flexion is 72º for Lumbar, 126º for cervical. Extension is 0º for lumbar and cervical

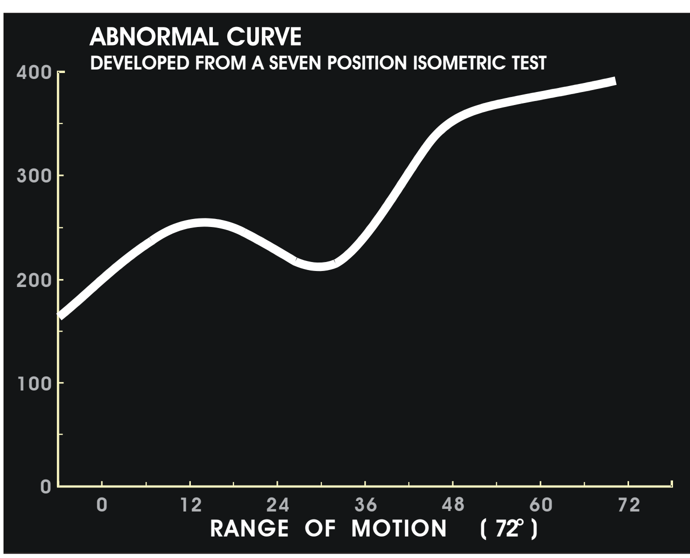
STRENGTH CURVES



Having performed static tests (isometric contractions) in several positions throughout a full range of movement, the monitor shows a bar-graph of torque in each position. A normal ratio of functional strength would show the highest level of torque in the flexed position (right) and the lowest level in the extended position (left), with proportionate levels in intermediate positions.



Based upon the torque measured in several positions, the computer will interpolate strength throughout the full range of movement. If the 'stored energy" option is selected, the monitor show not just functional torque but also a second line designating NMT (net muscular torque), distinguished by cifferent colors.



A normal "curve" is actually closer to being a straight line. The patient who produced the test result at left indicates a marked abnormality at approximately 30 degrees.

Potential for Strength Improvement

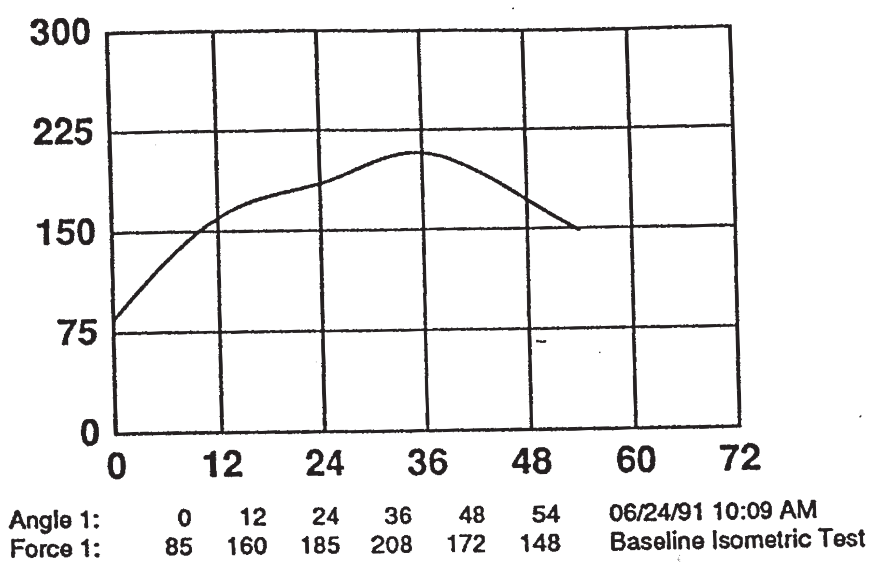
The patient's potential for strength development can be evaluated by comparing the patient's strength curve to the normal strength curve for healthy untrained individuals. When doing so, keep in mind that the ideal flexion to extension ratio is considered to be 1.4:1 (lumbar and cervical extension). Also, be sure to consider the patient's initial level of strength since relative improvements in strength are affected by training status.

Example: The following strength curve was obtained from a 30-year-old male patient at the start of his treatment program. Assume the short-term reliability has been established.

When compared to the age-matched average male strength curve, the patient's curve demonstrates the following characteristics:

Limited ROM

1) Below average strength
2) Two angles (54°, 48") disproportionately weak (abnormality)



Given the available information, it would be reasonable to assume that this patient will demonstrate fairly large increases in strength throughout the entire ROM. The greatest improvements would be anticipated at the 0, 48, and 54 degree positions. It would also be reasonable to assume that this patient will experience an increase in ROM, specifically in the flexed positions.

III. Determine the Patient's Fatigue Characteristics

The fatigue characteristics of the lumbar and cervical extensor muscles are assessed by comparing a measurement of maximal isometric strength (PRE FRT), to a measurement of isometric strength immediately following a set of dynamic exercise to volitional muscular fatigue (POST FRT). The average level of fatigue throughout the entire ROM is called the fatigue index, and is calculated using the following equation:

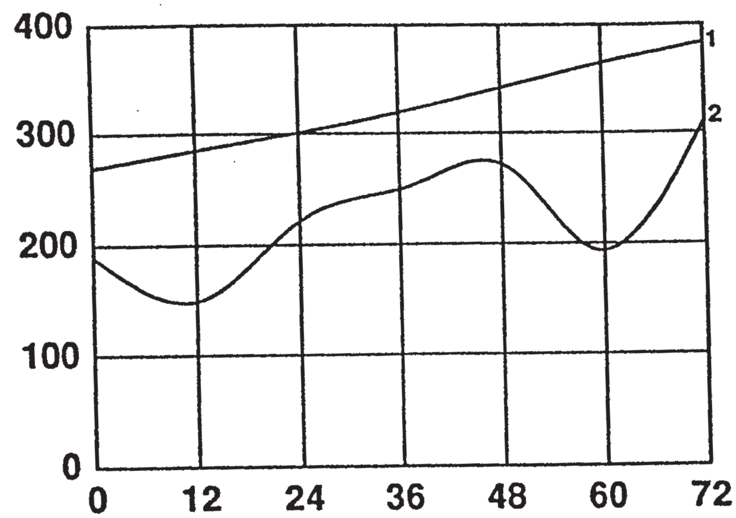
[(Sum PRE FRT - Sum POST FAT) / Sum PRE FRT] X 100 = _% avg fatigue

Example:

Sum PRE FRT (72°, 60°, 48°, 36°, 24°, 12°,0") - 2346
Sum POST FRT (72°, 60°, 48°, 36°, 24°, 12°,0") -1727
(2346-1727)/2346] x 100 = 26% average fatigue

As stated previously, a patient will sometimes fail to demonstrate reliable test results at one or two angles of measurement. When this occurs, omit the angles that appear unreliable from your calculations and use either a sum of 5 or 6 angles to determine the fatigue index.

For example, in the graph below, the measured fatigue at the 60- and 12-degree positions is disproportionate compared to the measured fatigue at the other five test positions. In this case, the force values at these two angles of measurement (60 and 12 degrees) would be excluded from your calculations.



Angle 1:	0	12	24	36	48	60	72	11/17/91 01:55 PM
Force 1:	270	284	296	314	346	367	385	PRE FRT
Angle 2:	0	12	24	36	48	60	72	11/17/91 02:09 PM
Force 2:	190	152	228	251	267	195	301	POST FRT

Sum PRE FRT (72°, 48°, 36°, 24°, 0°) = 1611
Sum POST FRT (72°, 48°, 36°, 24°, 0°) = 1237

[(1611- 1237)/1611] x 100 = 23% average fatigue

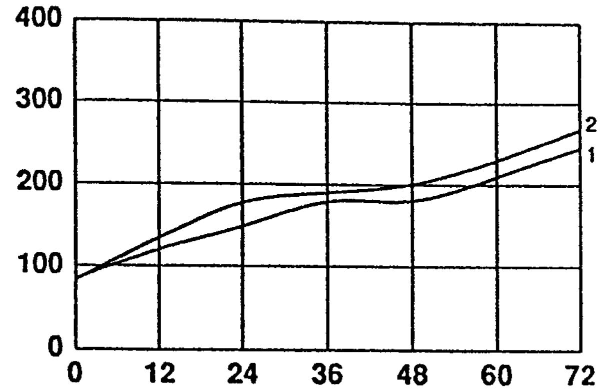
IV. Exercise Prescription

The information from a patient's strength curve(s) may be used to formulate the patient's exercise prescription. If the patient is not demonstrating improvements in strength or symptoms, the exercise prescription may need to be altered. In particular, the fatigue index can be used to establish a desired repetition range and training frequency when a patient fails to demonstrate progress with the standard treatment protocol. See "Clinical Fatigue Response Testing.'

Periodic re-evaluation of a patient's strength curve(s) is required in order to assess the effectiveness of the treatment program (long-term strength comparisons). Indicators of a successful treatment program include a significant increase in full ROM strength and a flattening of the patient's strength curve following 12 to 20 weeks of treatment. Research with healthy subjects has shown that the average lumbar extension flexion:extension strength ratio reached an 'ideal' ratio of 1.4: 1 following 20 weeks of training. Eventually, the patient may reach his or her potential for strength development. Indicators of a normal ending point in a rehabilitation program include a plateau in the patient's absolute level of isometric strength and dynamic training weight (no further increase in strength with continued training). When this occurs, a program of supportive care is recommended.

Study Problem #1

The following graph was obtained from a 200-pound, 35-year-old male patient during his first and second visits to the clinic:



Angle 1:	0	12	24	36	48	60	72	06/21/91 03:33 PM
Force 1:	84	120	148	179	180	210	245	Initial Isometric Test
Angle 2:	0	12	24	36	48	60	72	06/28/91 03:40 PM
Force 2:	83	134	177	190	201	230	268	Second Isometric Test

1. Does this subject demonstrate reliable test results? Use a short-term comparison to compare the curves in the figure (Hint: Calculate the variation between the two tests at each test angle, and determine if this is acceptable).

2. Does this Patient demonstrate full or limited ROM?

3. Are the shapes of the curves normal or abnormal?

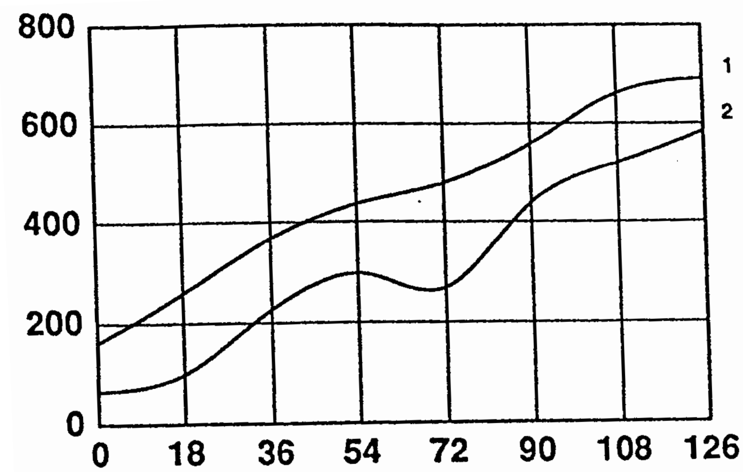
4. Calculate the flexion:extension ratio for the Second Isometric Test. What does this indicate?

5. Determine the percentile ranking at each measurement angle for this patient's ~ strength (use the Second Isometric Test).

6. Calculate this patient's relative strength at each measurement angle (use the Second Isometric Test).

Study Problem #2

The following graph presents the results of a Fatigue Response Test performed by a 200-pound, 28-year-old male patient:



Angle 1:	0	18	36	54	72	90	108	126	08/04/89 01:43 PM
Force 1:	161	258	368	437	480	558	662	692	PRE FRT
Angle 2:	0	18	36	54	72	90	108	126	08/04/89 01:50 PM
Force 2:	65	99	226	297	268	440	475	505	POST FRT W552 R10 T83

1. Compare this patient's absolute strength at each measurement angle to the average, healthy male (use Pre FRT).

2. Is the shape of this patient's strength curve (PRE FRT) normal? Why/why not?

3. Compare the patient's flexion: extension ratio (PRE FRT) to normal. What does this indicate?

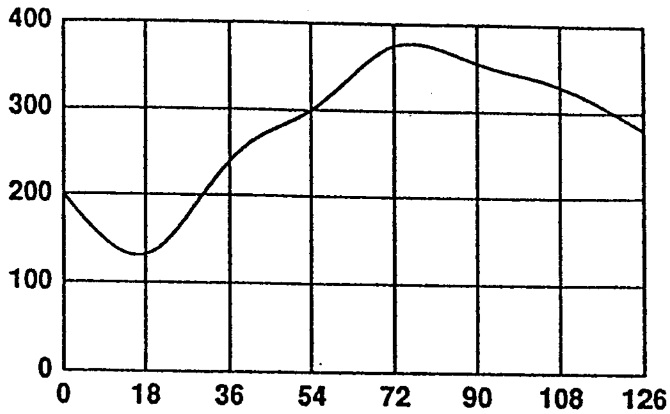
4. In terms of fatiguability, does this patient demonstrate reliability throughout the entire ROM?

5. Calculate this patient's fatigue index. Assuming that the patient bas not satisfactorily responded to the standard protocol, how would you alter the exercise prescription (repetition range; frequency)?

6. Describe any changes you would expect to see in the patient's strength curve consequent to a 12 to 20 week rehabilitation program.

Study Problem #3

The following graph was obtained from a 52-year -old male patient (assume that short term reliability has been established):



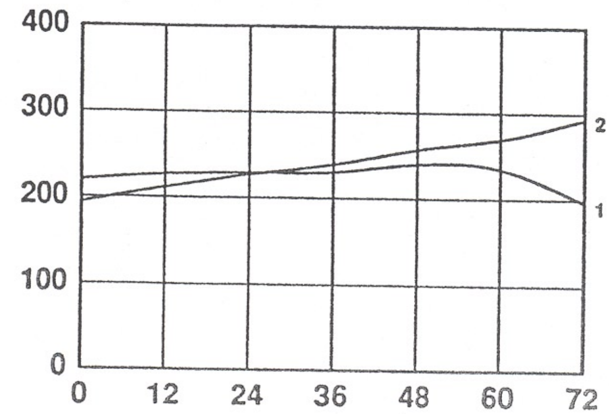
Angle 1:	0	18	36	54	72	90	108	126
Force 1:	200	132	240	300	374	355	330	280

04/14/90 10:01 AM
Baseline Isometric Test

1. Would you consider this a normal or abnormal strength curve? Why?
2. Calculate the flexion to extension ratio. Does this ratio accurately describe the shape of the curve?
3. Describe this patient's potential for strength development based on the information presented.

Study Problem #4

The following two strength curves were obtained from a 130-pound, 24-year-old female patient prior to and following 12 weeks of treatment:



Angle 1:	0	12	24	36	48	60	72	01/22/91 02:22 PM
Force 1:	220	227	229	230	240	235	197	Baseline Isometric Test
Angle 2:	0	12	24	36	48	60	72	04/19/91 03:10PM
Force 2:	194	212	227	239	257	269	293	12 WK Isometric Test

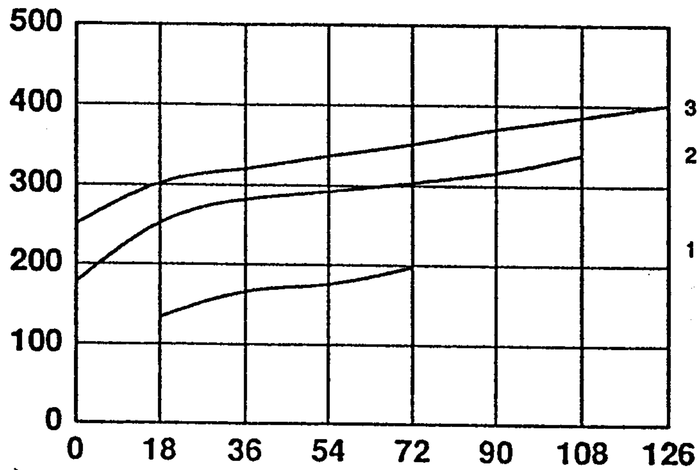
1. Compare this patient's strength curve following 12 weeks of treatment to a healthy, untrained female (consider all normative variables, ie. Shape, ROM, absolute and relative strength, flex/ext ratio).

2. Calculate this patient's percent improvement in strength at the 72° position.

3. If this patient were free of pain at the time of her 12 WK test, would you recommend that she continue in the rehabilitation program? Why/why not?

Study Problem #5

The following graphs were obtained from a 183-pound, 31-year-old male patient during his 12-week rehabilitation program:



Angle 1:		18	36	54	72				09/19/91 02:30 PM
Force 1:		134	166	176	198				INITIAL IM TEST
Angle 2:	0	18	36	54	72	90	108	126	11/17/91 01:55 PM
Force 2:	177	252	282	292	304	317	339		8 WK IM TEST
Angle 3:	0	18	36	54	72	90	108	126	12/20/91 12:37 PM
Force 3:	250	302	321	337	352	371	386	402	12 WK IM TEST

1. After 12 weeks of rehabilitation, compare this patient's flexion:extension ratio to normal.

2. Calculate the patient's average strength increase over the 12 week rehabilitation program? (Hint: This can only be calculated relative to the patient's initial ROM)

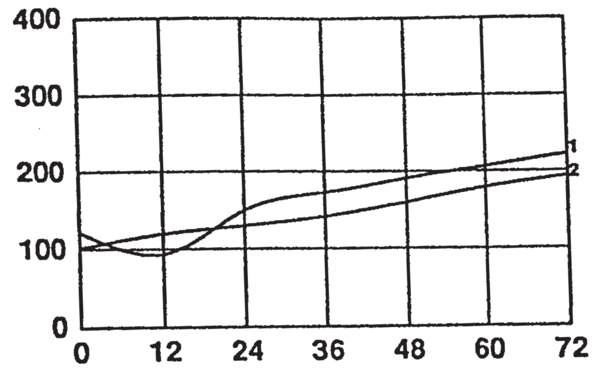
3. How much has this patient's ROM improved since the initial testing? (Expressed as a percentage).

Study Problem #6

The following graph presents the results of a Fatigue Response Test obtained from a 37-year -old female patient

1. Calculate this patient's fatigue index.

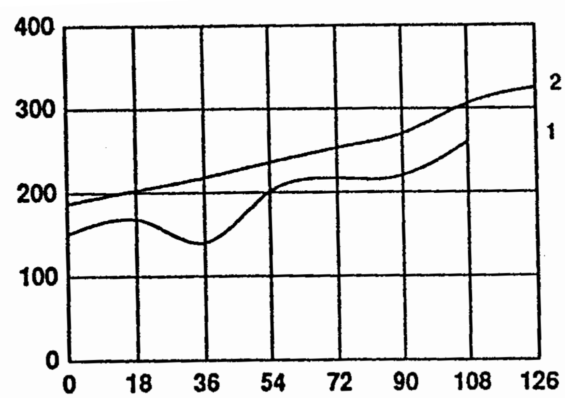
2. Determine this patient's absolute strength percentile ranking at all reliable test angles (use PRE FRT).



Angle 1:	0	12	24	36	48	60	72	07/07/90	04:41 PM
Force 1:	117	94	150	173	191	207	223	PRE FRT	
Angle 2:	0	12	24	36	48	60	72	07/07/90	04:46 PM
Force 2:	105	120	130	142	160	180	194	POST FRT	

Study Problem #7

The following strength curves were obtained from a 44-year-old male patient prior to and following 12 weeks of treatment:



Angle 1:	0	18	36	54	72	90	108	126	03/10/90	09:05 AM
Force 1:	151	168	140	201	217	220	260		Baseline Isometric Test	
Angle 2:	0	18	36	54	72	90	108	126	06/12/90	10:14 AM
Force 2:	187	203	218	236	253	270	306	325	12 Weeks	

1. How much has this patient's ROM improved since initial testing? (expressed as a percentage)

2. Calculate the average percent improvement in strength throughout the ROM from the Baseline Isometric Test to 12 WK.

Equipment Dimensions

Machine	Weight Stack (ft-lbs unless noted)	Machine Weight (pounds)	Dimensions (inches LxWxH)
Medical Machines			
Lumbar Extension	400	2144	61x88x76
Cervial Extension	900	1570	68x48x66
Core Spinal Fitness System			
Core Ab Isolator	300	828	58x64x74
Core Cervical	400	688	60x44x72
Core Torso Rotation	400	1075	58x78x73
Core Lumbar Extension	400	1127	76x46x79
Core Super Stretch	n/a	290	99x93x79
Selectorized			
Seated Rowing	500	876	42x63x77
Torso Arm	500	850	53x44x85
Leg Extension	500	902	59x38x77
Triceps	300	707	42x49x67
Pullover	2x300	1252	67x59x67
Chest Press	600	1030	42x53x82
Overhead Press	500	875	42x54x77
Seated Dip	500	797	42x44x77
Arm Curl	300	669	36x37x67
Arm Cross	400	850	42x52x76
Seated Leg Curl	400	678	37x61x67
Lateral Raise	300	735	42x57x67
Hip Abductor	300	680	78x42x67
Hip Adductor	400	780	78x42x72
Leg Press	2x500	2030	61x70x77