SPINE HEALTH AND WELLNESS

A five-part article introducing results and discoveries arising from a 40-year quest to improve prevention and cure of a world-wide endemic: chronic back and neck “disease” and the abundance of mechanical, spine-related maladies.

Upright Spine Solutions, LLC

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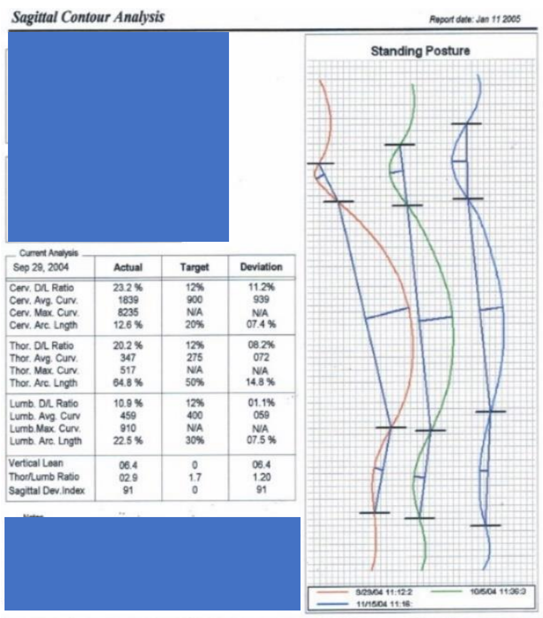
Restoring and Protecting the Amazing Spine

SPINE HEALTH and WELLNESS

Halliday, Michael V PT, Mooney, Vert MD, Momberger, Glenn MD, Loomis, J Howard PT DO, Call, C Boyd PT PhD, Church, Glen MD, Fox, Jeff MD, Sylvester, Jay PhD



Sep 29, 2004	Actual	Target	Deviation
Cerv. D/L Ratio	23.2 %	12%	11.2%
Cerv. Avg. Curv.	1839	900	939
Cerv. Max. Curv.	8235	N/A	N/A
Cerv. Arc. Lngth	12.6 %	20%	07.4 %
Thor. D/L Ratio	20.2 %	12%	08.2%
Thor. Avg. Curv.	347	275	072
Thor. Max. Curv.	517	N/A	N/A
Thor. Arc. Lngth	64.8 %	50%	14.8 %
Lumb. D/L Ratio	10.9 %	12%	01.1%
Lumb. Avg. Curv	459	400	059
Lumb.Max. Curv.	910	N/A	N/A
Lumb. Arc. Lngth	22.5 %	30%	07.5 %
Vertical Lean	06.4	0	06.4
Thor/Lumb Ratio	02.9	1.7	1.20
Sagittal Dev.Index	91	0	91

	Cervical				Thoracic				Lumbar				Result		
Date	D/L%	AvCU	MxCU	A/L%	D/L%	AvCU	MxCU	A/L%	D/L%	AvCU	MxCU	A/L%	Lean	T/L%	SDI
9/29/04 11:12	23.2	1839	8235	12.6	20.2	347	517	64.8	10.9	459	910	22.5	6.4	2.9	91
10/5/04 11:36	23	1181	3006	17.1	15.6	307	522	60	12.9	543	1054	22.9	4.5	2.6	56
11/15/04 11:16	21.4	917	2003	19.7	11.5	256	667	52.9	7.5	321	783	27.4	5	1.9	45

A lean forty-eight-year-old dock worker was referred for chronic neck pain caused by an industrial injury. Early retirement and partial disability were pending in his multi-year worker's compensation claim. However, he proved to be a compliant participant, met all program goals, and achieved satisfactory symptom relief and function gains within six weeks. He returned to full-time work and reported sustained satisfactory outcome at four years. (Please note changes in cervical spine shape.)

Four decades of clinical spine research confirmed that spine system recovery from mechanical decline and injury requires objective spine shape improvement as its foundational goal, followed by improved spine joint stability, spine region mobility and overall spine protection. This article is presented in five parts to introduce the reader to objective axial extension training and spine rebuilding as a front-line intervention and triage option for chronic back and neck sufferers, as well as other spine-related maladies.

Part I: Optimal Spine Shape

The 88-year-old mother of a referring MD presented advanced thoracic kyphosis and moderate to severe thoracic spine pain. NSAIDs were no longer an option. Six weeks of dedicated axial extension effort by the patient effectively reduced the kyphosis and eliminated the pain. However, both kyphosis and pain returned six months later due to excessive knitting while sitting in an old sofa. At age 89, shape improvement and pain elimination were again achieved but required three months the second time. Insufficient ability to objectively document the observed changes motivated development of better clinical techniques and technology, as described herein.

ABSTRACT

Sagittal shape of the human spine changes across the lifespan, from the prenatal, kyphosis-dominant "string of pearls" to lordosis-dominant prepubescent posturing, and on to the kyphosis-dominant deformity of aging. Forty years of longitudinal studies tracking retrovertebral contour and spine orientation using shape-digitizing technology discovered mathematical predictability in the rise and fall of spine shape. They also revealed that maintaining responsible shape is essential to spine wellness and a personal choice. Shape and orientation are defined in this five-part series according to sagittal proportionality, normality, and verticality with optimal values provided for each.

INTRODUCTION

Human spine shape is typically described to include rectilinear frontal plane orientation, absence of segmental rotation within the transverse plane, and possessive of three off-setting curves in the sagittal plane.[1,2] And while the literature includes discussion about kypholordotic relationships, it provides little objective measurement of optimal sagittal shape, vertical orientation of one curve above another, or objective quantification of sagittal shape changes across the lifespan.[3,4]

Early in our research we discovered that of the three anatomical planes, sagittal, frontal, and transverse, sagittal spine shape is the most dynamic, easiest influenced, and most reliably measured without imaging. Early studies also revealed that improving sagittal shape concurrently improves both frontal and transverse spine shape.[5] It therefore became the goal of this series of longitudinal studies to objectively define sagittal spine shape, mathematically track its lifetime changes, and learn how to effectively improve it. Part II will address shape degradation and related consequences, Part III discusses conservative optimization of spine shape, Part IV reviews the benefits of shape restoration, and Part V describes comprehensive strategies for achieving and preserving optimal spine shape and resulting benefits across the lifespan.

METHOD

Subjects

Subjects for this study belong to an open-ended sample of convenience that includes as many volunteers, measured as many times, over as many years as possible, without restriction to gender, age, race, or spine status. The only requirement for assessment participation is sufficient frontal plane neutrality, i.e., the spine's shape must be both reasonably linear and vertical within the frontal plane to permit two-dimensional, mid-sagittal shape assessment. Actual subject sample size is unknowable because it includes thousands of patients and volunteers who have been measured, instructed, and re-measured at one of 45 participating clinics and universities from 1987 to the present.

Spine Shape

Mid-sagittal spine shape is measured indirectly and assumed to reasonably resemble its superficial retrovertebral contour. Since repeated direct measurement of actual sagittal spine shape remains impossible, it was reasoned that inherent measurement error, which arises primarily from tissue thickness and spinous process length variability, remains relatively consistent across same-subject contourography, and can be statistically controlled during analysis. Additionally, it was determined that sagittal contour curves should be measured according to accepted mathematical curve-fitting convention[6] rather than by traditional Cobb angle measurement[7] that measures angles rather than curvature. Consequently, mid-sagittal curves are herein measured in terms of arc length, arc depth and average curvature. Simultaneous full-spine sagittal curve measurement also includes analysis of overall vertical orientation because verticality directly affects curve shape and vice versa.[8]

Equipment

Initial literature review preceding this study began in the early 1980's, included 1,200 peer-reviewed articles, and identified few reliable instruments or procedure options for tracking sagittal contour shape.[9-15] For our purposes, imaging procedures were excluded due to their expense, impracticality, and unnecessary subject risk. We also ruled out methods that collected curve data sequentially rather than simultaneously because of the possibility of spine shape change during point-by-point assessment, thus reducing reliability. Furthermore, it was deemed essential that all data harvesting must be expressly linear, precisely vertical, and capable of capturing all mid-sagittal contour data including sacral and occipital apices.

When no appropriate measuring tool could be located, it became necessary to develop a pneumatically deployed, vertically adjustable, linear contour gauge, capable of efficiently recording, digitizing, and analyzing all retrovertebral data points simultaneously for all qualifying subjects. The gauge has been previously described and its reliability and accuracy have been previously reported.[16-17] As one would expect, gauge reliability is greatest, approaching unity, when measuring known, rigid, geometric curves, but diminishes when measuring physiological curves. Subject curve assessment reliability for non-obese subjects exceeds .92 and decreases as BMI increases, unless mathematical correction factors are implemented to correct error. Similarly, comparison of superficial contour data with imaging-derived spine shape data indicates superficial contour validity is approximately .88 for non-obese subjects and again diminishes with increased BMI. We therefore conclude that superficial retrovertebral contour assessment is a sufficiently reliable and accurate option for measuring sagittal spine shape.[18]

Figure 1 Sagittal Contour Measurement

Procedure

Sagittal spine shape is measured by deploying the array of probes against the mid-sagittal spine while subjects stand at rest, bearing weight evenly and looking forward. Most subjects are measured while wearing trunks and gown or thin clothing. The resulting profile is scanned into a computer for curve-fitting and verticality analysis. Subjects are allowed to view current and previous tracings simultaneously, including mathematical analysis for each tracing.

Frequency

Some subjects are measured multiple times during and after training sessions to provide immediate curve shape feedback. Many subjects are measured weekly and monthly as part of their extended spine rebuilding program, and as many subjects as possible have been measured annually to track shape progress over time.

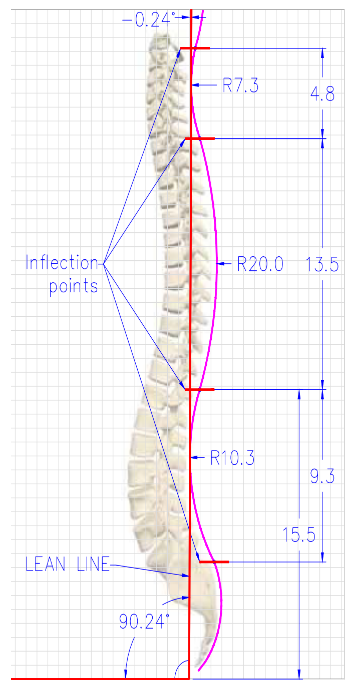


Figure 2 Sagittal Contour Analysis

Analysis

Verticality of the spine is measured by constructing a line from the lumbar apex to the cervical apex and measuring its deviation from absolute vertical. The procedure is convenient and reasonably reliable as stated in the literature.[19]

Proportionality of the retrovertebral contour's respective arc lengths is quantified by software analysis capable of locating inflection points or "centers of flatness between adjacent curves" that demark each region. Each curve's arc length can thereby be

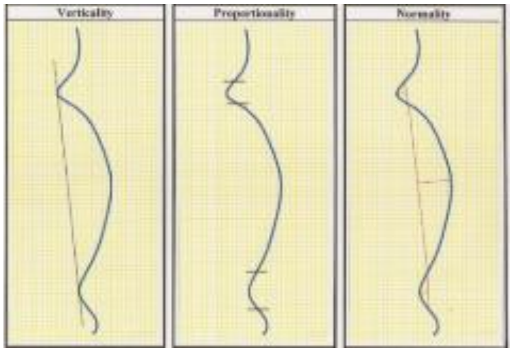


Figure 3 Kyphotic patient analysis

measured and subsequently converted to a percentage of total spine arc length, thereby creating a relative value for each concave or convex region. Cervical, thoracic, and lumbar arc length values always sum to 100%.

Normality or the "normalness" of each region's curve is measured in terms of its *depth to length ratio* and its *average curvature*. The former is a simple comparison of "between-inflection points" length divided into the curve's "perpendicular depth", given as a percentage.

Figure 4 Curvature Units

Curvature is a more involved calculation of average angular change between inflection points and requires use of "concentric circle" curve-fitting software. The curve assessment program determines the amount of bend for each arc in terms of *curvature units* or C.U.'s, which are similar to Diopters used to describe curvature of an eyeball or lens.[20] Calculating curvature values requires determining a round object's metric radius then dividing the result into1.0 to find the number's inverse. With optics, the shape is primarily geometric and possesses a single radius. In the case of spine curves, each arc is non-geometric and includes an infinite number of radii, longer to shorter and again to longer, as measured along the region's arc.

Defining non-geometric curvature requires determining the *average* radius across a specific arc length and then finding the inverse. When analyzing curves larger than that of the eyeball such as lumbar or thoracic arcs, the resulting inverse values are generally very small decimals and, by convention and for sake of convenience, are multiplied by a standard value to allow comparison of whole numbers.[21]

RESULTS

Since all participating subjects have been influenced by gravity and behavioral choices over their entire lifetime, no "perfect spine shape" control group exists for comparison of subject values to ideal values. Consequently, optimal values had to be determined by tracking spine metrics over time for subjects who participated in spine shape restoration, as described in Part III of this series. It was found that compliant subjects presented measurement values that steadily changed throughout their spine rebuilding program until they *plateaued* at a personal optimum. For example, verticality measurement often begins at six or seven degrees of forward lean and declines in magnitude during active shape rebuilding until subjects settle at approximately zero degrees of deviation, plus or minus two degrees. It was therefore deemed reasonable, as well as intuitive, to accept 0^0 of lean as optimal verticality. After the same phenomenon was observed with several thousand patients, 0^0 was accepted as the ideal vertical norm for a line connecting the two lordotic apexes. The same process of tracking active movement toward a natural plateau was eventually accepted for determining normative values for the other two metrics, proportionality, and normality, which includes curvature.[22]

Optimal norms for spine verticality, proportionality, normality, and curvature are-

Verticality (deviation from true vertical)
0^0

Proportionality (relative percentage of total spine arc length per region)

Cervical curve	20%
Thoracic curve	50%
Lumbar curve	30%

Normality (ratio of curve depth to linear curve length per region)

Cervical curve	12%
Thoracic curve	12%
Lumbar curve	12%

Curvature (inverse of the average radius per region, included in normality)

Cervical curve	900 CU’s
Thoracic curve	275 CU’s
Lumbar curve	400 CU’s

DISCUSSION

This on-going and comprehensive investigation reveals three previously unknown facts to be discussed across this five-part series. First, the commonly observed sagittal decline of the human spine system follows a mathematically predictable descent, measurable in terms of verticality, proportionality, and normality. Second, sagittal decline is primarily a personal choice and can be arrested and reversed under normal circumstances using conservative methods. And third, the course of sagittal return to optimum is also mathematically measurable and predictable and requires sustained effort. The discovery that spine shape can be reliably measured, positively changed, and effectively preserved across time is a remarkable revelation that promises countless applications in spine health care and the proper design and manufacturing of spine shape influencers i.e., vehicle seats, home and office furniture, and mattresses.

Criticisms

Criticism One. Critics believe this study has two fatal flaws and their indictments must be addressed before discussing the study’s findings and potential. The first criticism purports that spine curves are fluid in nature and can be purposefully re-shaped momentarily, thereby rendering attempts to accurately measure them meaningless.[23] In other words, anyone can change spine shape by simply standing or sitting more erectly. Suspecting this may be true, it became part of our protocol early in the investigation to ask subjects to stand at rest and then pose fully upright for a second measurement. Data from thousands of such test-retest trials made it clear that some spines can, indeed, achieve ideal sagittal values at will, and that those ideal values approach the same magnitude as derived by our “plateau-method” for proportionality, normality, and verticality norms. We remain grateful for the verification that healthy spine shape possesses predictable norms, exactly like medical sampling of body temperature, blood pressure, heart rate, and pO2 levels yields predictable values in healthy patients, each with some degree of acceptable error.

We also found that many subjects cannot instantaneously restore optimal spine shape, even with intense effort. Strained attempts to do so generally affect repositioning of extremity joints and exaggerate cervical spine extension but without affecting lumbar and thoracic shape, even though those regions may possess adequate mobility to allow change. We concluded that many individuals lose ability to assume optimal spine shape because of decreased kinesthetic awareness and reduced muscle control, more so than because of loss of joint mobility. For others, joint rigidity is certainly a contributing limiter, as confirmed by spine flexibility studies to be published later. Regardless of the cause, this study confirms that spine shape commonly departs from shape norms over time and can be mostly restored to those standards with effort. That fact overshadows the unavoidable, and yet informative observation, that some subjects can normalize spine shape at will.

Criticism Two. The second criticism arises from literature that claims spine symptoms and function are unrelated to spine shape.[24] Our research finds that spine function is unavoidably related to spine shape, as demonstrated by the hyperkyphotic patient who lives with scapular protraction and excessive cervical extension. Such a patient commonly complains of inability to look or reach upward as far as when they were younger and admits that trying to do so causes discomfort. Curve assessment of this subject finds exaggerated curvature values in both cervical and thoracic regions along with verticality deviation that is anterior in orientation and well above normal. Goniometric evaluation reveals reduced motion in neck and shoulder joints.

The patient is then trained in axial extension and achieves significant improvement in thoracic and cervical curvature, as well as reduced anterior lean. It is reasonable that such changes should reduce apophyseal impingement and improve the arthrokinematics of the cervical spine. Similarly, reduced thoracic kyphosis and diminished anterior lean should encourage scapular retraction thus reducing subacromial impingement. Re-measurement of the reduced-kyphosis patient’s cervical and shoulder range of motion finds significant increase in motion and reduction in end-range discomfort. In this case, extension training directed exclusively toward improving spine shape simultaneously improved motion, function, and symptoms.

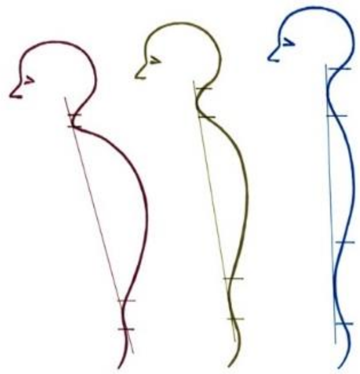
CONCLUSION

The results of this protracted study confirm the age-old belief that individuals should "stand or sit up straight" or suffer unstated consequences. We now have a better understanding as to what "up straight" means, and we also have greater understanding of what those consequences are. It is inevitable that sagittal spine shape will ascend and descend during the lifespan metamorphosis. The extent, the direction, and the costs of shape changes for most individuals are confirmed here to connect directly with personal choice.

Primary developments/discoveries associated with Part I

1. Digital spine contour assessment can be reliable
2. Spine shape possesses predictable norms
3. Spine shape metamorphosis across the lifespan is mathematically predictable
4. Spine regions possess predictable norms for range of motion

Part II: Spine Shape Decline and Related Consequences



A 74-year-old male displayed reduced lumbar lordosis, advanced thoracic kyphosis, and excessive cervical extension. His chief complaints included chronic LBP, chronic cervical pain, and cervical crepitus. Daily axial extension effort improved all three curves and eliminated both pain and crepitus. His shape progress across five weeks is represented here using early technology.

Abstract

Multiple longitudinal investigations involving large numbers of back and neck pain patients across four decades discovered two commonalities: 1) all individuals eventually display subtle decline in spine shape and overall stature, and 2) nearly all individuals eventually report spine-related complaints. Part II reveals the profoundly positive correlation between spine shape decline and spine related symptoms, as determined inversely by tracking declining symptom prevalence vs. shape improvement. Statistical analysis confirms that correlation between spine shape and spine symptoms exceeds .9 and statistical forecasting predicts that ICC's will approach .99 when the final general population correlation is determined.

INTRODUCTION

Genu varum loads menisci disproportionately and predicts premature failure of the medial meniscus. Chronic bruxing predicts premature tooth failure. Excessive pronation predicts hallux valgus and MTP exostosis. In the spine, imbalanced forces cause structural changes that alter prevailing forces and predict deformity and painful consequences. Experienced clinicians observe two things across their career. First, they witness the structural decline of their patients. And second, they become obliged to respond to their patients' universal complaints of back and neck pain.

Part II explores the mechanical and medical consequences of axial decline of the musculoskeletal system and introduces a new clinical label, Skeletal Degeneration Syndrome (SDS). Related orthopedic, neuro, and visceral conditions are listed later, each connected directly or indirectly to altered forces and conditions associated with structural collapse of the bi-pedal human frame.

Deformation of sagittal spine shape across the lifespan is commonly accepted as an unavoidable part of life. Wolff's Law predicts it.[25] Our numerous and protracted studies investigated the cause and correlation between spine shape deterioration and eventual development of symptomatic conditions.

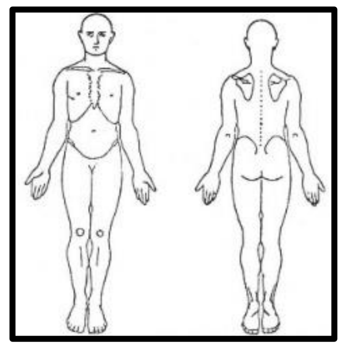
METHOD

Subjects and Procedure

As described in Part I, subjects for this on-going study belong to an open-ended sample of convenience that includes as many patients and volunteers, measured as many times, over as many years as possible, without restriction to gender, age, race, or spine status. Again, sample size is unknowable because it includes thousands of individuals who received sagittal contour measurement and analysis during longitudinal comparison at one of 45 participating clinics from 1987 to the present.

Symptom Assessment Questionnaire

The following self-reporting tool was devised to better objectify symptom documentation. The purpose was to quantify symptoms more accurately and allow meaningful comparison between severe symptoms experienced infrequently and mild symptoms experienced constantly. All participants were asked to complete the questionnaire during all spine shape measurement sessions.



Please circle area(s) of pain or symptoms on the drawing and then circle the number in each row below that best describes those symptoms. You may identify more than one area by using a circle for one area and a box or check mark for another. Do the same to match the row scores to the associated area(s).

How INTENSE are the symptoms you experience in this area?

6	5	4	3	2	1	0
Unbearable	Severe	Strong	Medium	Mild	Faint	None

How OFTEN do you experience symptoms in this area?

6	5	4	3	2	1	0
Constantly	Hourly	Daily	Weekly	Monthly	Rarely	None

How LONG do symptoms in this area last?

6	5	4	3	2	1	0
Day & Night	All Day	Most of Day	Hours	Minutes	Seconds	None

How SUCCESSFUL are you at relieving these symptoms by moving or repositioning?

5	4	3	2	1
Fully Unsuccessful	Mostly Unsuccessful	Partly Successful	Mostly Successful	Fully Successful

Symptom Scoring: ADD the first 3 rows' scores and MULTIPLY the total by the 4th row score to determine your Symptom Score. The range is 0 to 90.

Your Symptom Score should be less than 10. ALL SYMPTOMS should be reported to your medical doctor! However, infrequent, low-grade back/neck discomfort scoring 10 or less is common to the human condition and is not usually linked to disease or injury.

RESULTS

Optimal spine shape values were described in Part I and include ideal verticality of the vertebral column, ideal proportionality of the three sagittal arc lengths, and ideal normality of sagittal curves to include optimal depth-to-length ratios and curvature for each region. It was also noted previously that optimal spine shape in frontal and transverse planes is directly related to optimal shape in the sagittal plane.

The purpose of Part II is to define and report common spine shape deviation found in modern society and to compare the deviation from optimal shape values to self-reported symptoms and dysfunction.

Verticality

Analysis of sagittal verticality measurement reveals three general result categories, 1) individuals who generally stand fully uprightly (vertical group), 2) individuals who chronically lean backward behind absolute vertical (posterior lean group), and 3) individuals who habitually lean forward of absolute vertical (anterior lean group).[26]

Note: Serial verticality testing reveals that individuals do not typically fluctuate from group to group. Almost all subjects display the same basic vertical orientation from test to test unless they purposely invest sufficient effort over sufficient time to alter it.

Vertical Group: Individuals found in this group presented less than two-degrees of lean in either sagittal direction and were typically individuals who reported that they valued good posture and usually tried to stand or sit uprightly. Most group members reported a specific reason for seeking upright posturing including 1) training from parents, 2) training associated with music, dance, or athletic performance, and 3) strategy to diminish pain from previous spine injury. Former halo traction patients were the most strikingly erect subgroup within the Vertical Group.

Posterior Lean Group: Individuals who chronically lean backward belong to the smallest group and present a negative lean of two to six degrees. They fall into one of only two subgroups, 1) compensatory balancers, and 2) those with an idiopathic, genetic pre-disposition for negative lean. The former group is more common and consists mostly of barrel-chested males and macromastic females who lean slightly backward to keep their center of mass over their base of support. The latter subgroup is small, often includes siblings, and their posterior lean appears to be genetic in origin because they are most often ectomorphs who have no obvious mechanical reason to lean backward. It is sometimes said that they prefer to “hang on their Y-ligaments”, referring to the iliofemoral ligaments.[27]

Anterior Lean Group: This is by far the largest group and includes all races, all ages, both genders, all occupations, and all lifestyles. The average group member presents an anterior lean of six degrees. Group range is from three to 25 degrees, with some individuals so profoundly deformed anteriorly that assessment is not reasonably possible. For reference, it is interesting that the Leaning Tower of Pisa had to be structurally rescued when its lean exceeded the same six degrees, and yet its height-to-base ratio, and therefore its "tip-ability", is only half that of the average adult.[28]

Proportionality

With modest exception, proportionality deviation presents a dominating adult category: increasing thoracic arc length and compensatory reduction in lumbar and cervical arc lengths. Thoracic arc length should be 50% or less of combined sagittal arc length values. Young and healthy thoracic spines are predictably less than 50% but sagittal decline begins with the falling of the thorax, thus lengthening its arc to upwards of 70% of total. Healthy cervical and lumbar spines present arc lengths that exceed 20% and 30% respectively, for a combined arc length total of 100% (20+50+30).

If thoracic curve grows to 75%, that leaves only 25% of combined length to be shared by cervical and lumbar arcs. Since five healthy lumbar vertebrae commonly comprise 30% of total arc length, that means each lumbar vertebra contributes 6% to total spine arch length. When thoracic elongation robs the lumbar region of length from 30% to as little as 12%, lumbar vertebrae don't shrink in size, they simply change teams. The upper three lumbar lordotic vertebrae convert from lordotic load bearers to kyphotic load bearers, leaving the lower two lumbar vertebrae to do the work of five. Similarly, three cervical vertebral units are forced to do the work of seven.

Normality

Normality refers to normal curve shape and is measured in terms of inflection point-to-inflection point length, divided into its perpendicular depth, and is also measured by its curvature. Normality deviation is divided into three subgroups.

1) Hypo-lordotic lumbar, hyper-kyphotic thoracic, and hyper-lordotic cervical curves. This is by far the most common normality deviation pattern, is dominated by males, and is almost always associated with exaggerated anterior lean.
2) Hyper-lordotic lumbar, hyper-kyphotic thoracic, and hyper-lordotic cervical curves. This pattern is much less common, is dominated by heavier/buxom females, and is almost always associated with little vertical deviation.
3) Hypo-lordotic lumbar, hypo-kyphotic thoracic, and hypo-lordotic cervical curves. This pattern is least common, is dominated by thin individuals of both genders, is common among female ballet dancers and presents little or no vertical deviation.

Curvature refers to the fullness and smoothness of a given spinal curve, and parallels ability as a load bearing "spring" to efficiently absorb superincumbent forces. Curvature deviation commonly falls into three categories, 1) ideal curvature, 2) insufficient curvature, and 3) excessive curvature. Ideal curvature values were provided in Part I. Insufficient curvature indicates a curve is flatter than optimal, possesses 0 to 300 CU's, and is most commonly found in the lumbar spine. Excessive curvature is most commonly found in the thoracic and cervical regions, measures more than 325 CU's in the thoracic spine and more than 1,000 units in the cervical region, and is more often related to body image, personal habits, and occupation than to gender.[29]

Symptoms

The average beginning spine program participant scores about 40 on the 0-90 scale shown above. This indicates that the respondent experiences medium discomfort, occurring daily, lasting hours, and that he or she is mostly unsuccessful reducing the discomfort by changing position or activity (3+4+3 = 10, multiplied by 4 = 40).

By way of comparison, progressing participants often report symptoms that are mild to medium in intensity, occurring daily to weekly, lasting minutes to hours, and responding better to position and activity change, scoring less than 20. Successful patients typically report symptoms that are faint to mild, occurring weekly to monthly, lasting seconds to minutes, and fully relieved with position and activity change, yielding a score below 10.

Participants with acute spine pain report severe symptoms, occurring hourly, lasting most of the day, and unresponsive to position or activity change. Their Symptom Index (SI) score is usually in the upper 50's or 60's. Scores higher than 60 are uncommon and are considered indicative of either a serious condition requiring immediate medical attention, or agenda-biased pain assessment manipulation. Maximum scores are rare and indicate unbearable, constant, day & night pain that is fully unresponsive to changes in position or activity, thus scoring 90 on the SI scale.

DISCUSSION

With the understanding that spine shape tends to change under chronic, protracted, load-bearing conditions, it is naive to believe that change occurs without consequence, without affecting the integrity of its own structural components, or without compromising the volume and function of structures it ceases to fully support and protect. For example, as the dorsal spine and thorax trend forward and downward, the change certainly results in measurable loss of thoracic volume and compliance, thereby likely affecting pulmonary function. Wallentine et al found that such conditions, even in college-age subjects, compromise dynamic ventilation by as much as 10%, an insidious loss the COPD patient can ill-afford.[30]

Radiographic studies and skeletal model analysis indicate that the flexed thoracic spine and downward rotated trunk adversely affect scapular and rib positioning, resulting in reduction of subclavian space and thus potentially impacting the brachial plexus and subclavian vessels.[31,32] Additionally, numerous authors comment upon the resulting loss of subacromial space associated with trunk flexion and scapular protraction, thereby impinging the rotator cuff tendon, sheath, and bursa.[33,34] The forward fall of the unstable trunk is therefore not innocuous and can subtly inflict tissue damage. Evidence that the thorax can be restored to a more efficient position without invasive intervention should hold promise for the advancing kyphotic patient with pulmonary insufficiency, Thoracic Outlet Syndrome, or shoulder impingement.

Advanced alteration of any spine curve affects its function and threatens the wellbeing of its components. For example, the mass of the thorax habitually falls forward from its lumbar perch as the lumbar curve flattens. The fall causes excessive thoracic kyphosis and the kyphosis forces exaggeration of cervical lordosis in order to hold the head upward while maintaining visual line of sight. The domino effect from lumbar to thoracic to cervical, including scapular protraction, are found in our studies to foster the following mechanical consequences.[35-38]

1) Impingement of-
    a. Suboccipital nerves, secondary to muscle shortening and tension
    b. Cervical nerve roots, secondary to anterolateral IVD bulging
    c. Cervical apophyseal joints, secondary to excessive approximation
    d. Subclavian vessels, secondary to thoracic outlet narrowing
    e. Subacromial tendon and bursa, secondary to downward orientation of the glenohumeral joint
    f. Acromioclavicular joints, secondary to rotational compression
    g. Sternocostal joints, secondary to excessive compression
    h. Pleural cavity, secondary to prevention of thoracic expansion
    i. Lumbar nerve roots, secondary to posterolateral IVD bulging
    j. Iliocostal separation, secondary to extreme thoracic fall
    k. GI system, secondary to advanced costal fall
2) Subluxation of-
    a. Lumbar apophyseal joints, secondary to chronic distraction
    b. Thoracic apophyseal joints, secondary to chronic distraction
    c. Sacroiliac joints, secondary to repetitive distraction
    d. Costovertebral joints, secondary to repetitive rotational distraction
3) Other
    a. Muscle distress, secondary to paraspinal reduction in Length-Tension balance
    b. Kinetic/kinematic chain alteration affecting lower extremity components
        i. Patellofemoral compression
        ii. Hamstring shortening and tightening
        iii. Triceps surae shortening and tightening
        iv. Tendinitis, tendinosis, and fasciitis
        v. Exostosis

CONCLUSION

In the absence of a control group free from spine shape deviation and spine symptoms, the only way to know if spine shape change affects spine symptoms is to alter spine shape and evaluate the impact shape change has upon symptoms. This is intuitive to every LBP sufferer who learns early that alteration of lumbar shape increases or decreases symptoms.

A Scandinavian study in the 1960's crudely measured spine shape and compared shape data to self-reported spine complaints. They concluded there was no correlation between shape and symptoms, and their considerable sample size caused their declaration to be widely accepted, which quieted the existing debate about posture and pain.[39]

However, their design had a fatal error that mislead an entire generation of clinicians. They measured spine shape of thousands of dock workers and assigned each worker to a symptom or no symptom group. Since most dock workers present similar occupation-influenced spine shape and since symptom presence for manual laborers changes from day to day depending on workload and personal circumstances, it was impossible to identify if one variable actually influenced the other.

For the purpose of our long-term investigational goals, it was necessary to purposely improve subject spine shape, seeking previously determined optimal shape values, and analyze the effect upon spine complaints. Strategies, techniques, and tools were devised and refined to effectively move spine shape data toward established norms while simultaneously monitoring subjects' self-reported changes in spine-related symptoms. The following histogram reveals the relationship of both variables, plus a dysfunction metric, across one year for several hundred compliant spine patients.[40]

Initial measurements established a baseline of spine shape deviation (SDI), total symptoms (SxI), and total dysfunction (DI). Although the number of participants declined over the 52-week period due to attrition, statistical analysis confirmed that function and symptoms improved directly in relationship to participants' ability to improve axial extension.

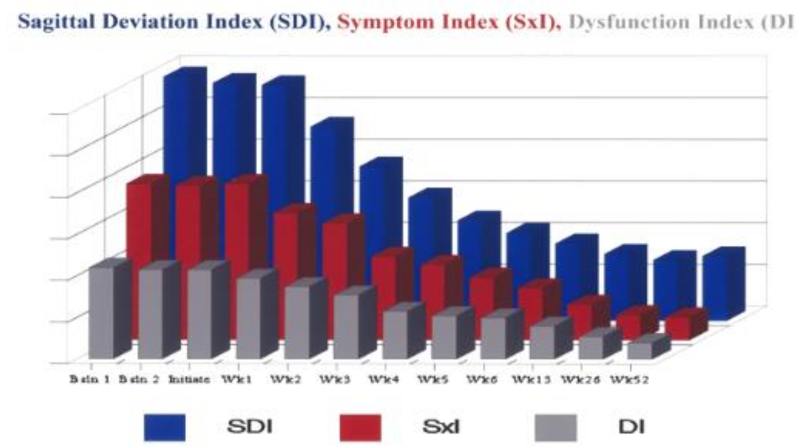


Figure 1   Shape vs Symptoms vs Dysfunction

Not surprising is the fact that many successful spine rebuilding participants become complacent after symptoms decline and life returns to normal. The graph below belongs to a 50-year-old male whose progress was charted across 43 months.[41] It reveals initial, significant, spine shape deviation that preceded a major lumbar event. The data shows that the patient then improved axial extension skills following the event but still required seven months to recover from the symptoms. With symptom levels accepted by the patient as "good as it's going to get", his dedication to axial extension principles steadily waned until a second serious event occurred 30 months after the first. The second

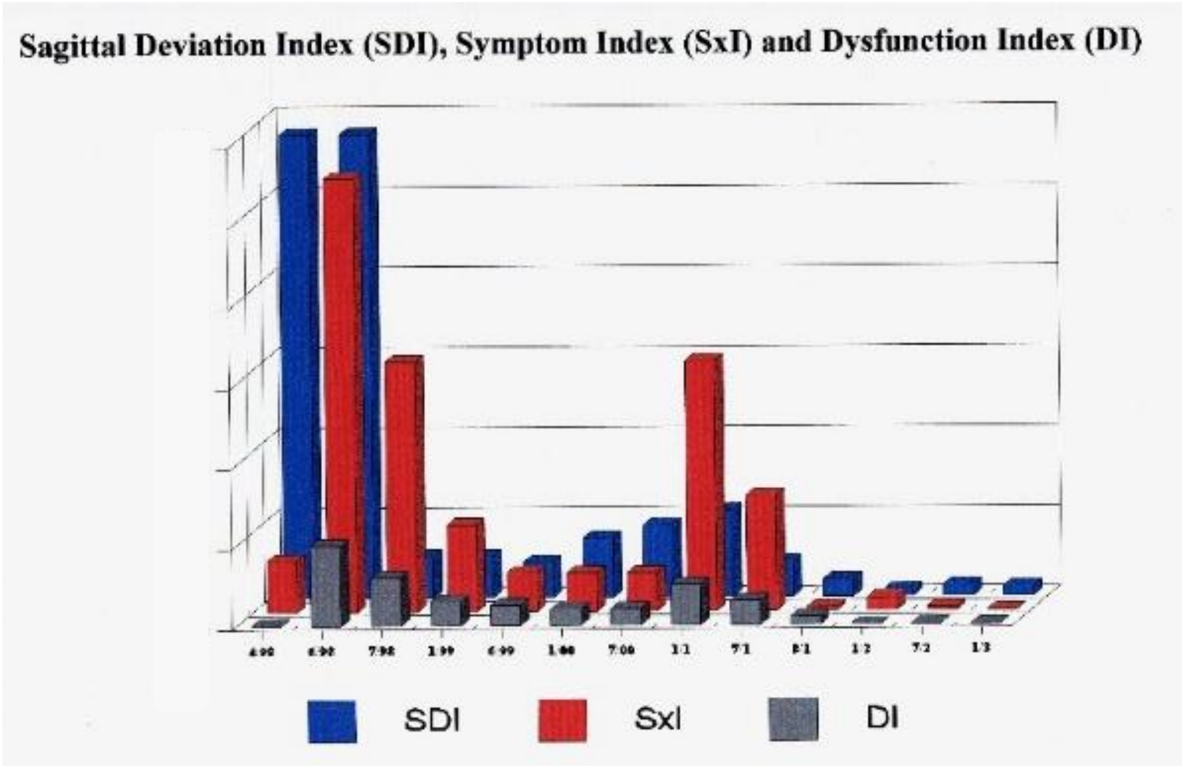


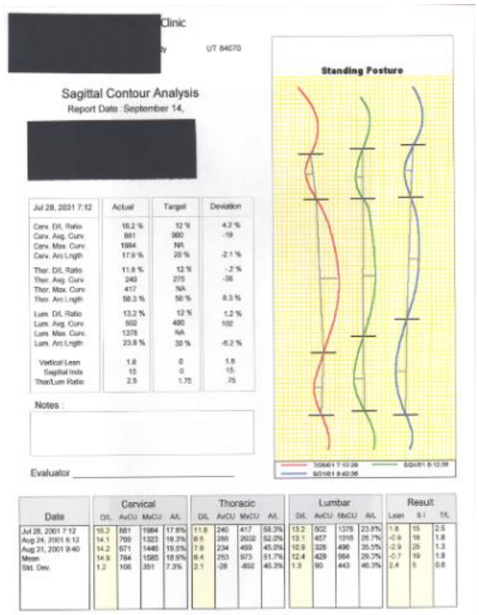
Figure 2 LBP Case Study: Shape vs. Symptoms vs. Dysfunction
Note: Timeline not drawn to scale

event was severe enough to remind him of the greater severity of the first event and convinced him to better adopt spine wellness principles going forward. The chart reveals that his resolve significantly improved spine shape, symptoms, and function across the remaining 24 months of the record. This case and countless cases like it, support the conclusion that spine symptoms and spine dysfunction are directly related to spine shape deviation.

Primary discoveries associated with Part II

1. Skeletal Degeneration Syndrome predictably causes nerve, vessel, and musculoskeletal conditions associated with mechanical impingement
2. Skeletal Degeneration Syndrome predictably causes musculoskeletal conditions associated with mechanical distraction
3. Verticality degradation is predictably associated with Skeletal Degeneration Syndrome
4. Sagittal spine shape proportionality and normality degrade predictably and can be mathematically monitored
5. Kinematic decline can be objectively monitored, and its affects predicted

Part III: Conservative Spine Shape Improvement



A 44-year-old dentist displayed diminishing lumbar lordosis and advancing thoracic kyphosis. He complained of episodic LBP and a chronically subluxing right-side costovertebral joint that made upper molar injection risky for his patients and painful for him. He traded services with a chiropractor for daily rib reduction, but eventual L4-5 HNP forced more serious effort to keep him working. His spine rebuilding program was fully successful. (Please note Sagittal Contour Analysis evidence of reduced thoracic kyphosis and increased lumbar lordosis after five weeks.)

Abstract
Forms of spine bracing have been used for centuries in the attempt to affect spine shape when spine deformity is present. However, the typical kypholordotic changes associated with the aging process have been generally ignored and accepted as an unavoidable consequence of growing older. Because longitudinal investigations confirm that declining spine shape begins young and directly promotes spine symptoms and dysfunction, Part III provides an overview of how patients can use conservative measures to effectively arrest and reverse deformity of their own spine system.

INTRODUCTION

Society is familiar with ancient practices of foot-binding, skull shaping, and use of neck rings to apply external force to compel bones and joints to grow into a selected shape.[42] Modern orthodontia uses hardware to achieve the same goal. This section discusses the orthopedic principle of Wolff's law and how it can be favorably employed using conservative measures over time to restore the declining spine to more optimal shape norms.[43] It introduces three spine laws and four spine rebuilding goals.

Orthodontia can successfully relocate teeth and their bony sockets at almost any age. However, post-hardware patients must typically wear retainers to prevent teeth from returning to their previous location and some patients must use a retainer indefinitely. Similarly, the spine system's more than 60 bones and 200 joints also remain dynamic across the lifespan and are indefinitely subject to reshaping influences according to Wolff's principles, as proven by the spine's perpetual tendency to deform downward. Improving spine shape requires application of sufficient force, correctly oriented, over a sufficient length of time, to stimulate desired bone remodeling. Applied force must also successfully resist the natural tendency that allows bone, joints, and supportive tissues to default back to previous conditions.

INTERVENTION

Shape Assessment. All subjects must be measured and analyzed for verticality and spine shape before beginning axial extension training and all willing participants are re-measured periodically across the entirety of their training program.

Axial Extension Education. Subjects are introduced to axial extension training principles via videos, models, and one-on-one demonstrations. Depending upon the specific research study subjects participate in, some receive group education in one or two classroom sessions while others participate in personal teaching sessions across four to eight weeks.

Goals and Laws. Spine rebuilding centers around meeting and maintaining four program goals: 1) improve spine shape, 2) improve segmental stability, 3) improve regional spine mobility, and 4) improve spine protection. Subjects are also taught to follow three lifelong spine protecting laws: 1) Choose to live uprightly, 2) Correctly use and protect the spine's curves during all activity, and 3) Nourish the spine system with hydration, diet, and especially motion.

Axial Extension Training. Following education experiences, most subjects are trained in various versions of axial extension techniques with one-on-one demonstrations and coach-directed participation. Some subjects are trained in extension techniques that require no tools while others participate in programs that utilize unique axial extension devices designed and built for their specific needs, 1) the Axial Extension Trainer, 2) the UpLifter, and 3) some patients receive a custom-fit dynamic spine extension exercise device known as the Spine Sentry (not shown below).

Iliocostalis Muscle Groups. Careful anatomical evaluation including cadaver dissection reveals an important difference between the orientation and attachment of most Sacrospinalis muscles and the Iliocostalis muscles. While most spine extension muscles, including the Iliocostalis lumborum insert on the spine and/or inferior border of the lower six ribs, Iliocostalis thoracis tendons insert on the upper, anterior margins of the upper six ribs.[44] The insertion distinction is critical because the tendons wind over the top of each rib and rotate the rib upward and rearward during contraction. In conjunction with the Iliocostalis lumborum's lower anchor, the sternum is thereby elevated, and the ribcage is lifted and expanded.[45]

Figure 1 Axial Extension Trainer

Axial Extension Trainer. Extensive patient evaluation determined that the average person has difficulty isolating contraction of the Iliocostalis thoracis and requires assistance to re-learn how to do so, especially older patients. To that end, the Axial Extension Trainer was developed to isolate, awaken, and strengthen the Iliocostalis group. Pad placement allows users to prevent unwanted hip and lower back extension permitted by typical back machines, and isolate extension of the spine above the fulcrum pad while users push against the resistance pad located above it. Adjusting the fulcrum pad up the track increases the work the thoracis muscles must perform because it further isolates thoracic extension. Adding exercise bands for bilateral shoulder external rotation and scapular retraction exercises, performed simultaneously with axial extension exercises, greatly reinforces axial control. Two-way mirrors provide visual feedback to improve body awareness and promote proprioception skills.

Figure 2 UpLifter

UpLifter. Spine assessment often reveals that patients have allowed thoracic decline to persist for so long that the spine has become less mobile and less capable of participating in axial extension training. The discovery prompted development of the UpLifter and its numerous predecessors, all designed to gently exercise and improve thoracic and lumbar range of motion while in a sitting position. Patients find the activity universally comfortable, symptom relieving, and helpful mentally, anatomically, and physiologically.[46]

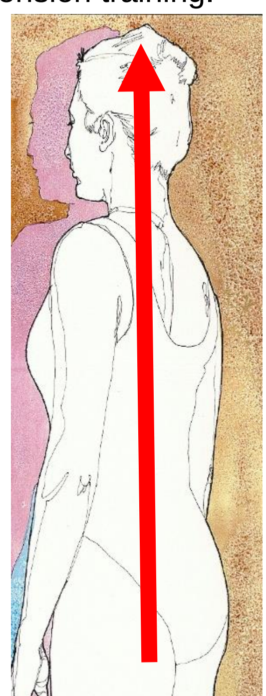


Figure 3 Isometrics

THERAPEUTIC EXERCISE

While the above devices have proven to be important in isolating and training the Iliocostalis thoracis and other spine extensor muscles, it is intuitive that patients must adopt daily habits that also isolate and strengthen the Iliocostals while strengthening inner and outer core muscles. To that end, patients are trained in a series of isometric exercises designed to target all musculature that lifts and stabilizes the spine and thorax. Isometric contractions are taught to be performed during specific activities throughout a patient’s normal daily routine rather than as a daily exercise session, which most people mean to do, but don’t.

Participants are also encouraged to blend axial extension with all forms of aerobic exercise that permit it. Normal and power walking lead the list of effective activities, but all other aerobic varieties are encouraged if they allow lumbar extension while not exaggerating thoracic flexion or cervical extension. To that end, road bike enthusiasts, for example, require special technique training and bike configuration until they are fully recovered and safe to return to normal riding.

ACTIVITIES OF DAILY LIVING (ADL) TRAINING

Effectively training participants to adopt axial extension principles into all activities of daily life is paramount to ultimate program success. Episodic axial extension exercises, even if performed daily, do not effectively improve core extension habits unless the individual also practices improved extension skills while actually living life. As mentioned above, participants are measured periodically across their training program and beyond to help them observe their own progress, thereby advancing upright skills from “rental” to permanent ownership.

The Uprightly online ADL Video Library provides participating individuals a resource for learning and review. For example, it teaches suffering office workers how to accurately set up their office at home and at work to precisely match their spine system needs. It then teaches them how to work at a desk safely. Library videos also teach individuals how to work safely in their yard or garden, how to clean a tub or shower, and how to vacuum, clean floors, play tennis, and go bowling without risking spine re-injury. Instead of the historical predisposition to warn sufferers about all things they shouldn’t do, our participants are taught and trained to safely do all things they want and need to do.

RESULTS

The average compliant participant improves in all spine shape categories, as evidenced by the Sagittal Index (SI) score (sometimes referred to as the Sagittal Deviation Index score or SDI). The SI is a weighted tally of all sagittal shape deviation and is used for convenience in tracking and reporting changes in shape and verticality. An SI score between 0 and 30 is considered ideal on its open-ended range. Individuals with common spine problems typically score from 60 to 100 and advancing sagittal deformity is revealed with scores between 100 and 200. Profound sagittal deformity is associated with SI scores greater than 200. The average individual can improve their SI score by 30-50 points within six weeks and learn to maintain achieved goals within six months.[47]

DISCUSSION

Two successive years of spine shape assessment involving regional Miss America Scholarship contestants found the average contestant scored 17 on the Sagittal Index scale while the average score for their mothers was 77. The results suggested that the average contestant mother successfully teaches her daughter excellent upright skills while neglecting her own.

While assessing the correlation between improved spine symptoms and function and improved spine shape, all studies revealed that effective axial extension education and training significantly improves all three variables. All case studies, repeated studies, and open-ended studies achieved the same results, including studies performed by independent researchers at independent clinics. Because the implications are so fundamental to spine and overall wellness, the discovery that axial extension discipline predictably reduces all varieties of spine symptoms, dependably improves spine shape and stature, and predictably improves spine system function cannot be overstated.[48,49]

Compliance studies found that participants who invest the most effort over the most time achieve the best results and that participants who initially invest effort but do not sustain that effort eventually revert back to initial conditions. Not surprisingly, individuals who invest only token effort achieve little or no benefit. Long-term studies show that axial extension principles become imbedded within foundational motor memory for compliant individuals who adopt them for life.[50,51]

CONCLUSION

Sustained improvement in spine verticality, shape, symptom, and function remains proportional to sustained effort to internalize axial extension skills and principles.

Primary discoveries associated with Part III

1. Sagittal spine shape can be significantly improved with effort
2. Sagittal shape improvement is achievable at any age
3. Iliocostalis thoracis upper six tendons are key to axial extension
4. How to isolate and retrain Iliocostalis thoracis muscles
5. Effective principles for reversal of sagittal degradation
6. Sagittal degradation reversal patterns

Part IV: Benefits of Spine Shape Improvement

A 91-year-old female complaining of painful iliocostal impingement was referred for axial extension training and proved to be a motivated participant. By week three, stature increased two inches, rib-on-ilia crepitation ceased fully, and she complained good-naturedly of increased bowel activity.

Abstract
Ninety-eight percent of all spine rebuilding participants who meet program goals enjoy two or more of four primary benefits, including diminished symptoms, improved spine function, improved appearance, and improved confidence in ability to use the spine without experiencing pain. Ninety-three percent report outcome satisfaction that includes all four benefits.

INTRODUCTION

Method and Subjects were described previously.

RESULTS

An especially revealing investigation involved approximately 1,000 patients referred for spine care by area practitioners. All patients were invited to participate in a spine rebuilding program that included a guaranteed outcome for compliant participants who completed six weeks of instruction, training, and progress assessment. Compliant patients who met the program's four basic goals were promised the option to pay for received services or not, based on their level of satisfaction. Dissatisfied patients were even guaranteed refund for all fees paid by their insurance company, thus creating an intentional incentive to misrepresent their outcome. All mechanical spine conditions were accepted into the program regardless of history or pathology, excluding patients with significant spine fusion.

Five hundred and ninety-seven patients began and completed the program and 555 patients or 93% reported full satisfaction. Of the 42 dissatisfied patients, 32 or 5.4% reported no symptom improvement but stated they were satisfied the program helped them improve upright appearance and taught them better techniques for functioning with symptoms. They chose not to request a refund. The remaining 10 patients reported no program benefit and accepted a return of paid fees. Combining the full and partially successful outcome groups found that 98% of all compliant participants reported a positive outcome that included two or more benefits while only 2% failed fully.[52]

DISCUSSION

Compliant patients, as defined by our studies, are those who pursue, achieve, and maintain improved spine shape, stability, mobility, and protection. Additional studies revealed that nearly all subjects who suffer from mechanical spine conditions, who are without significant fusion, and who have been medically screened for fracture, infection, cancer, and disease are candidates for spine rebuilding and are expected to achieve most or all of the benefits including improved symptoms, function, appearance and confidence.[53]

Sustained Benefits

The value of any treatment protocol lies in its capacity to deliver sustained benefits. Intervention, invasive or non-invasive, that brings speedy symptom relief will always be appreciated by the sufferer until symptoms return. When an intervention is costly or never-ending and the period of delivered relief is disappointingly brief, sufferers become disillusioned and move on to another form of treatment, which may also bring temporary relief until it no longer does. Review of the medical literature and popular websites reveals over 70 passive spine pain remedies that require nothing more from the sufferer than to take a pill, submit themselves for treatment by someone, or purchase a device for self-treatment at home.[54] The well-known 1994 landmark study by Stan Bigos, et al, confirmed that passive low back remedies have no long-term value.[55]

Successful spine restoration demands active participation by all sufferers and active spine rebuilding studies reveal that successful graduates predictably receive the results they earn. Unfortunately, long-term studies also reveal that the average compliant patient eventually loses motivation to maintain their goals after symptoms no longer burden their daily life. Depending upon the extent of the pathology, patients are often able to “coast” for three to six months after completing their spine recovery program, but symptoms commonly return.[56]

A study involving university students applies well to our investigation.[57] Researchers found that healthy student subjects who remained at total bedrest for one week required fourteen weeks to regain the bone and muscle mass they lost during the single-week confinement. Our work and other physical therapy studies found that muscle strength declines rapidly following injury or surgery and rebuilds very slowly.[58] The average knee patient loses 35 to 40% of quadriceps strength almost immediately after serious injury and requires five to six months to return to 85% of full strength. In fact, athletes often comment even after strength has returned to pre-injury levels that the limb still doesn’t feel “normal” for up to an entire year. Their perception is accurate, likely related to loss of pre-injury proprioception acuity. The latter loss places the individual at risk of re-injury when they insist on athletic participation before the knee is fully healed. The same is true of recovery from spine system injury.[59]

Spine system restoration requires dedicated goal attainment and goal maintenance, but also requires permanent internalization of those goals. The successful spine patient remains compliant to spine preserving principles over time. When life's distractions cause a spine system misstep, the spine-educated individual knows how to immediately deal with the consequences and is skilled in regaining the spine health he or she enjoyed before the error. The more quickly the individual correctly manages spine-straining events, the more quickly and more effectively the incident will be contained and resolved.

Follow-up studies found that over 90% of compliant patients and approximately 70% of partially compliant patients report sustained spine benefits over all ensuing years. In other words, the more a former spine sufferer maintains spine nurturing and spine protecting principles, the more likely they are to enjoy sustained benefits of a healthy spine throughout their lifetime.[60]

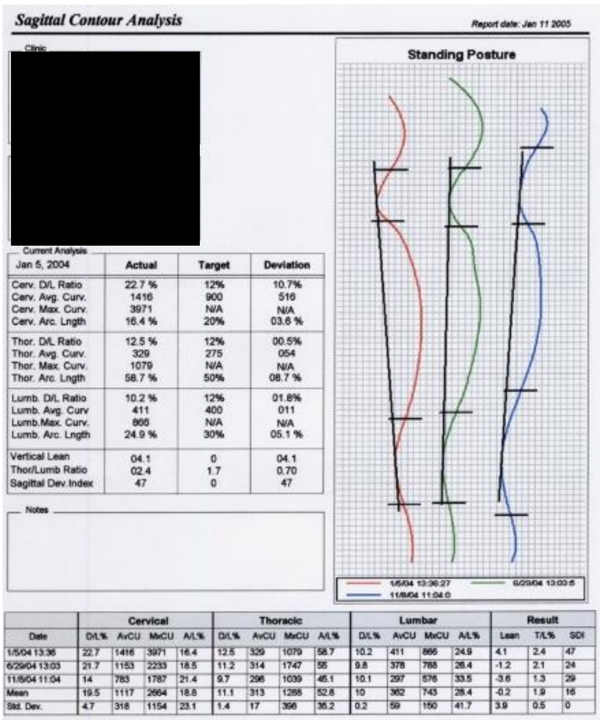
CONCLUSION

Spine restoration participants who not only achieve but also dutifully maintain their spine rebuilding goals have a 93% chance of experiencing all spine recovery benefits including symptom control, improved function, improved appearance, and improved spine confidence across the remainder of their active lifetime.

Primary discoveries associated with Part IV

1. Structured, goal-oriented axial extension training is universally effective
2. Most spine sufferers are willing to participate in structured, goal-oriented axial extension training they trust to be effective
3. Sustained compliance to axial extension principles yields sustained benefits over time

Part V: Spine Shape and Benefits Preservation



Sagittal Contour Analysis — Report date: Jan 11 2005

Clinic [redacted]

Current Analysis

Jan 5, 2004	Actual	Target	Deviation
Cerv. D/L Ratio	22.7 %	12%	10.7%
Cerv. Avg. Curv.	1416	900	516
Cerv. Max. Curv.	3971	N/A	N/A
Cerv. Arc. Lngth	16.4 %	20%	03.6 %
Thor. D/L Ratio	12.5 %	12%	00.5%
Thor. Avg. Curv.	329	275	054
Thor. Max. Curv.	1079	N/A	N/A
Thor. Arc. Lngth	58.7 %	50%	08.7 %
Lumb. D/L Ratio	10.2 %	12%	01.8%
Lumb. Avg. Curv	411	400	011
Lumb.Max. Curv.	866	N/A	N/A
Lumb. Arc. Lngth	24.9 %	30%	05.1 %
Vertical Lean	04.1	0	04.1
Thor/Lumb Ratio	02.4	1.7	0.70
Sagittal Dev. Index	47	0	47

Notes

	Cervical				Thoracic				Lumbar				Result		
Date	D/L%	AvCU	MxCU	A/L%	D/L%	AvCU	MxCU	A/L%	D/L%	AvCU	MxCU	A/L%	Lean	T/L%	SDI
1/5/04 13:36	22.7	1416	3971	16.4	12.5	329	1079	58.7	10.2	411	866	24.9	4.1	2.4	47
6/29/04 13:03	21.7	1153	2233	18.5	11.2	314	1747	55	9.8	378	788	26.4	-1.2	2.1	24
11/8/04 11:04	14	783	1787	21.4	9.7	296	1039	45.1	10.1	297	576	33.5	-3.6	1.3	29
Mean	19.5	1117	2664	18.8	11.1	313	1288	52.8	10	362	743	28.4	-0.2	1.9	16
Std. Dev.	4.7	318	1154	23.1	1.4	17	398	36.2	0.2	59	150	41.7	3.9	0.5	0

A 72-year-old kyphotic, buxom, retired, female office worker with chronic upper back and neck pain was referred for care and axial extension training. Her participation was exemplary but without reward following three months of dedication to a clinic and home program. Follow-up assessment at six and ten months revealed improvement in spine shape and the patient reported satisfactory decrease in spine symptoms. She attributed her eventual success to continuation of exercise, dutiful attention to standing and sitting uprightly knowing she would be periodically re-evaluated, and use of a lumbar shape-enhancing orthosis whenever she sat, including while driving. (Note the significant shape change affecting all three vertebral regions and the increased posterior lean adopted to better balance her macromastia.)

Abstract
Effective spine restoration requires comprehensive intervention and sustained post-intervention management.

INTRODUCTION

This fifth and final part of *Spine Health and Wellness* discusses how to effectively achieve and preserve optimal spine shape, spine function and spine symptom control throughout one's active lifetime. The challenges for long-term success are obvious. First, it is a natural human tendency to regress to previous habits, and second, we live in a physical world that fosters mechanical regression. Our homes, our workplaces, our furniture, our vehicles, and all public transportation are designed to fit the statistically average human being even though very few of us are the actual size and shape of the average person. Restated, our mechanical world fits almost all of us poorly and encourages Wolff's Law to insidiously deform us away from ideal skeletal shape and vertical orientation for an entire lifetime. Therefore, those who choose a healthy spine and musculoskeletal system must also chose to earn them and fight to keep them.

COMPREHENSIVE MECHANICAL SPINE CARE

Restoring and maintaining a healthy spine system, the foundation of a healthy musculoskeletal system, includes six elements: authoritative supervision, objective analysis, education, mentored training, progress monitoring, and continued support.

Medical Supervision

Our research indicates that the primary care provider (PCP) plays two essential roles in comprehensive spine care: diagnosis and authoritative oversight. Mechanical spine conditions must be accurately differentiated from medical conditions due to dangerous symptom overlap. Patients also deserve to be directed away from temporary remedies and toward assuming responsibility for their own spine wellness by someone they trust.[61]

Objective Analysis

Symptoms, function, and spine shape must be measured as objectively and as frequently as possible. Self-reporting instruments have proven sufficiently accurate for the first two variables, but spine shape is neither readily visible nor are spine curves intuitively understandable. Objective spine shape assessment requires digital, mid-sagittal curve tracing and computerized curve analysis that meet scientific standards of reliability, accuracy, and sensitivity to change. Other metrics must be similarly dependable, and all results must be made understandable for the sufferer.

Need-Specific Education

Each spine sufferer has unique spine education needs but does not need to become a back expert. Patients deserve, however, to understand why they experience spine symptoms and why and how they must become involved in their own spine recovery. Spine education is delivered effectively in classroom and one-on-one settings but is more available with online videos. Comprehensive spine care places the sufferer at the center of influence and empowers them, with direction from a mentor or coach, to efficiently manage their own spine wellness. Patient education is foundational to this process and parallels physical re-training.

Need-Specific Re-Training

Every spine patient has unique needs for neuromusculoskeletal re-training and deserves whatever tools and guidance are necessary to help them eventually achieve their spine recovery goals. The process takes time and effort and requires instruction, demonstration, practice, supervision, and repeated assessment with immediate feedback from their mentor.

Progress Management

Similar to other forms of behavior modification such as weight management, spine sufferers value access to scheduled, objective monitoring of their symptoms, function, and spine metric progress. Sustained success involves months of practice and years of integration with re-assessment to help guide them through the distractions and demands of life.

Comprehensive Support

Sustained spine success requires four forms of support: 1) continued access to an expert who can help with problems and questions when they arise, 2) opportunity to re-view all education and training materials whenever needed, 3) periodic progress re-assessment, and 4) spine supporting tools. The first three components have been described previously but the fourth element involves accurate spine-to-surface interfacing that deserves explanation.

Sleep Surface

People lie on a mattress upwards of 3,000 hours per year. All mattresses eventually fail, and most sleepers continue to use a failed mattress too long because replacement is an unwelcome expense. Their choice is unwise and hastens subtle spine degeneration.

A new mattress of good quality possesses sufficient resistance (ability to “catch” falling mass) and resilience (ability to “lift” falling mass) to support the spine in its optimal shape and alignment. Conversely, a hard floor provides resistance but without ability to lift. Anyone who has fallen asleep on a wood or tile floor knows they awaken stiff and sore. The pain arises from compression of protruding bones and joints and the stiffness is associated with fatigued muscles that were forced to support falling curves and spine segments to the point of “splinted” rebellion. By comparison, a sagging mattress loses both resistance and resilience, thereby inviting Wolff’s Law to deform the user’s spine and trigger avoidable consequences as quickly as braces move teeth, which is within weeks.[62]

Since almost all mattress construction includes foam, our investigation targeted all types of foam, analyzing their capacity to support weight bearing, ability to rebound after weight removal, and durability over time. We found that all foam begins to permanently collapse as soon as it begins to bear weight, even though changes are not immediately visible. Research also revealed that some foam types fail faster than others and that HD foam, the type found in most mattresses, reaches critical failure levels in less than one year.[63]

Mattresses are able to properly support the spine no better or longer than the resistance, resilience, and durability of their energy-absorbing components (springs, liquid, foam, gel, fibers, feathers, down, straw, etc.) permit. In other words, a mattress is only as supportive as its weakest components can provide support. Springs are best because they last longest, up to 20 years. But air, water, and viscoelastic (memory) foam are worst because they inherently displace so readily, they immediately abandon critical areas where spine support is essential.[64]

Of greatest importance, we discovered that mattress sag is a critical measure of mattress worthiness. Careful clinical investigation comparing sag magnitude and effect upon suffering users revealed that troubled spines tolerate no more than 16mm (5/8") of lumbar sag, depending upon pathology. That value is far less than the 1.5" to 2.5" of sag manufacturers claim to be necessary for "normal nesting".[65,66]

The vertebral column depends upon the inflation of its discs for stability. Spine injury and degeneration typically reduce disc turgor and introduce instability at afflicted levels. When standing, gravity pushes vertebrae together and increases stability, but sleeping invites gravity to dislocate an unstable segment from between its neighbors. Chronic lateral forces upon unstable spine segments cause joints to ache from compression or distraction and muscles to hurt due to fatigue caused by exhaustive splinting.

Patient requests for objective guidelines to help them select a better mattress obliged us to dissect and analyze old mattresses to analyze their failure. Mattresses discarded by our patients were especially valuable in analyzing both the mattress and the mattress user to match symptoms with component breakdown. The continuing project permitted us to establish a list of five critical criteria that must be met by all mattresses sold for use by customers with spine problems. When major manufacturers proved unwilling to meet these criteria, we designed and built mattresses that do. User satisfaction is currently above 95%.[67]

Office Chairs

Many office workers sit chained to a screen, keyboard, mouse, and phone for 2,000 hours per year. Our investigation of several thousand computer workers revealed that 67% report spine-related discomfort on any given workday. The same study found that workers take turns visiting the spine pain pool on different days and that less than 5% report no spine symptoms.[68]

When patients and government agencies asked for assistance purchasing the "best" office chairs, we examined 200 ergonomic, computer, and task chairs, evaluating each one from the vantage point of how to safely seat the injured or unstable spine that must work at a desk. That perspective brought the curiously wide array of seating models into sharp focus and required us to blend physics, anatomy, ergonomics, orthopedics, anthropometric data, and our own optimal spine metrics into the investigation.

We eventually learned that seating products are not just something to sit on but are orthopedic appliances that permit Wolff's Law to unavoidably alter user spine shape to match any chair's contour within a surprisingly short period of time. The analysis concluded that chairs dedicated to extended office work must meet 15 critical criteria or they expose users to known, predictable, orthopedic injury. When no chair was found that met all criteria, and after meeting with major office chair manufacturers in the U.S. and abroad, we became obligated to design and build chairs that do. User satisfaction is approximately 97%.[69]

Portable Spine Support

Patients asked for help eliminating spine pain from travel. We investigated the phenomenon of requiring a fragile spine to sit in a vibrating vehicle seat while being constantly exposed to omnidirectional forces associated with starting and stopping, acceleration and deceleration, left and right turns, bumps and jars for hours per day and possibly thousands of hours per year.

We found that prevailing travel forces foster forward and downward settling of the torso, while causing the lumbar spine to compress and deform rearward into the seat back. The process distracts apophyseal joints, posteriorly displaces and compresses lumbar discs, and alters length and strength of spine extensor muscles, even while all components are called upon to work harder. Resulting consequences are minimal during short trips but induce pain and stiffness during extended travel that should be seen as a warning of anatomical insult, structural fatigue, and pending deformity.

Intuitively, achy travelers support the lumbar spine with fists, books, bottles, pillows, and anything available, but we found that lumbar support must be more specific than that. Support must selectively target the mid-sagittal lumbar spine and medial thorax without crowding buttocks or scapulae. Accurately shaped and properly placed lumbar support helps lift and stabilize the upright, correctly shaped spine during long trips.

To that end, we designed and produced a portable orthotic device that adjustably matches both lumbar arc shape and vertical location of the lumbar curve above the vehicle seat while providing paraspinal support. The device delivers prescriptive lift and shape retention for use while traveling and for sitting in public seating. Long-distance travelers report dependable pain control and patient satisfaction is greater than 95%.[70]

Serial Assessment

The most important element in providing sustained support for the healing spine is serial assessment. Tracking symptoms alone provides insufficient feedback because spine pain is "last semester's report card". Periodic shape, verticality, and scapular placement assessment helps spine owners monitor current conditions of their framework. It permits real-time measurement of changes arising from any and all influencers. Measurement before and after prolonged travel reveals the impact of the vehicle's seat. Evening and morning shape assessment reveals the impact of the mattress. Before and after work assessment reveals the shape impact an office chair had upon its user. The governing tenet for effectively fostering spine wellness is maintaining and objectively monitoring its degree of uprightness.[71]

Online Tutorial Library

A commonality across all spine patient groups has been the tendency to forget what they once knew and lose spine skills they once owned. In response to their pleas for subsequent help and reminders, we developed an online library with video training classes and ADL tutorials to help forgetful sufferers refresh their memories. The classes and tutorials also remind patients to annually allow their PCP to confirm that their complaints remain mechanical in origin.

RESULTS and DISCUSSION

Comprehensive spine care is effective triage for all mechanical spine system complaints. Almost all individuals will eventually experience spine system complaints. At least 60% of all sufferers will complete a spine rebuilding program if given the opportunity, and over 90% of complaint participants will report a satisfactory initial outcome. More importantly, 90% of patients who remain loyal to the maintenance of their spine wellness goals will remain satisfied with the function and wellness of their spine system over time.[72,73]

However, experience has shown that most individuals are skeptical and unwilling to participate in a spine recovery program without some understanding and without encouragement from someone they trust. They are most likely to begin and complete spine rebuilding when someone they trust is aware of their progress.

An injured 55-year-old machinist had received permanent disability from workers compensation and was awaiting early retirement and a settlement. However, he was then required to participate in spine rebuilding before he could claim his benefits and came to our clinic angry because we threatened his windfall. He reluctantly agreed to a two-week trial and eventually completed the six-week program with careful guidance from someone he respected. Following program completion, he withdrew his W/C claim, forfeited the settlement, and returned to full-time work. When asked “why” at a workers compensation review he said he didn’t really want to retire. He loved his work. He just was tired of working in pain. With symptoms gone and function returned, he was pleased to go back to his job and successfully did so.

CONCLUSION

All discoveries presented in this five-part article arise from arduous investigation that spanned four decades, involved a statistically responsible number of clinicians and scientists, engaged with a very large but unknown number of patients and volunteers, and included a reasonably large number of independent research locations. The resulting volume of new knowledge eventually gave birth to a patient-centric spine care and restoration program that delivers predictable and sustained outcome for all compliant participants, regardless of spine history or pathology, age, gender, or race. It represents a new paradigm for successful prevention, care, and restoration of mechanical spine conditions and we believe that every individual deserves the opportunity participate in it.

Primary discoveries associated with Part V

1. Essential criteria for construction of portable mid-sagittal spine orthotics
2. Essential criteria for construction of spine-safe office seating
3. Essential criteria for construction and use of a spine-safe mattress
4. Effective strategies for engaging spine sufferers in responsible self-care, spine restoration, and spine maintenance
5.

SUMMARY STATEMENT

It is our concluding opinion that the design and function of the human spine system is exquisitely complex and currently beyond the full understanding of medical science. Misguided claims that the spine is defective might be reasonable, given the world-wide prevalence of back and neck problems, except for two incontrovertible facts.

Fact One. There is no precedent for a universally defective organ or system anywhere within the human body.

Fact Two. Effective restoration of spine verticality and optimal spine shape predictably improves spine health and wellness for every compliant sufferer. Spine wellness is indisputably connected to spine shape, segmental stability, regional mobility, and degree of spine protection.

02.24.22

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INITIAL ANTHOLOGY

Michael V Halliday MS PT
1996

Measurement and Significance of Sagittal Spine Curves

1. The fetus in utero and the new-born baby have a column which is gently convex backwards from the base of the skull to the lumbosacral joint. This long gentle curve, including that of the sacrum, are known as the primary curve of life.

   In adult life, however, this primary curve is present only in the thoracic region and the sacrum. In the neck and lumbar regions, the curves have become convex forward and these are the secondary curves…The two secondary curves are those where there is great mobility and in the lumbar region the forward curve is almost entirely due to the thick intervertebral discs. It is commonplace that nearly all the problems of the spine occur in these two areas.

   Rhodes P: Backache as a gynecological problem. The Practitioner 202: pp.344-350, 1969

2. Cervical and lumbar lordosis develop prenatally…distinct cervical forward curvature in 90 mm embryos and marked lumbar lordosis in 155 mm embryos.

   Med M: Prenatal development of intervertebral articulation in man and its association with ventrodorsal curvature of the spine. Morphologica 28: pp. 264-267, 1980

3. The spinal column and the attached musculature are designed to support the weight and gravitational forces that are superimposed on it. Thus there is a normal lumbar lordosis, thoracic kyphosis, mid-lower cervical lordosis of 30- 35 degrees and a slight kyphosis in the sub-occipital region. The presence of different curvatures in the cervical spine allows for forward and backward bending of the head, independent of the mid-lower cervical spine.

   Mannheimer J, Rosenthal M: Acute and chronic postural abnormalities as related to craniofacial pain and temporomandibular disorders. Dental Clinics of North America 35: pp.186-204, 1991

4. For subjects undergoing clinical and x-ray measurements at intervals of up to 10 years, where no growth or pathologic deformation factors are to be taken into account, the clinical and x-ray measurements of kyphosis and lordosis are remarkably constant.

   Stagnara P, DeMauroy J, et al: Reciprocal angulation of vertebral bodies in a sagittal plane: Approach to references for the evaluation of kyphosis and lordosis. Spine 7: pp. 335-342, 1982

5. It is known that two vastly different spinal curvatures may in fact have the same Cobb angle, Voutsinas and MacEwen pointed out the limitations of Cobb measurements in describing the sagittal contours of the spine; they more accurately described the sagittal curves by reporting indices of kyphosis and lordosis, based on *curve length and width*.

   Internal fixation should be predetermined to maintain kypholordotic balance.

   Bernhyardt M, Bridwell K: Segmental analysis of the sagittal plane alignment of the normal thoracic lumbar spine and thoracolumbar junction. Spine 14: pp. 717-721, 1988

6. Voluntary pelvic tilt did not alter the thoracic spinal curve. For both the Healthy Group and the Patient Group, the lumbar curve was altered by the pelvic tilt: anterior tilt increased the depth of the lumbar curve and posterior tilt decreased the depth of the lumbar curve. The amount of pelvic tilt was the same whether knees were extended or flexed 10 degrees. Pelvic tilt also tended to influence the orientation of the head and other parts of the body.

   Day J, Lehmann T: Effect of pelvic tilt on standing posture. PT 64: pp. 510-516, 1984

7. The (Intra-tester) Pearson correlation coefficient for the 92 paired measures (flexicurve) was .97. Validity was assessed by comparing data obtained with the flexible ruler and from x-ray data using standard technique correlating angles (with curves)…the authors found .87 correlation.

R-040 Research presentation, No author given: Reliability of non-invasive methods for measuring the lumbar curve. PT 62: pp. 642, 1982

8. When comparing the two groups, we found a tendency for a greater amount of lordosis in pregnant women but this difference was not statistically significant at the .05 level. There was also a tendency for greater anterior pelvic tilt. (Iowa Anatomical Position System)

   R-039 Research presentation, No author given: Comparison of spinal configuration in pregnant and non-pregnant women. PT 62: pp. 641, 1982

9. The thoracic and lumbar curvatures of 105 Nigerian adults have been measured with a flexicurve. The lumbar curvature is relatively greater in women. Compared with a previous survey of Europeans, the curvatures in both men and women appear to be 20 per cent greater in Nigerians. This is likely to be a genetic difference but the Nigerians practice of carrying heavy loads on the head may be a contributory factor.

   Patrick J: Thoracic and lumbar spinal curvatures in Nigerian adults. Annals of Human Biology 3: pp. 383-386, 1976

10. Muscles imparted stability to the ligamentous segment. The presence of muscles also led to a decrease in stresses in the vertebral body, the intradiscal pressure and other mechanical parameters of importance. The load bearing of the facets increased compared to the ligamentous model. Thus facets play a significant role in transmitting loads in a normal intact spine.

    Goal V, et al: A combined finite element and optimization investigation of lumbar spine mechanics with and without muscles. Spine 18: pp. 1531-1541, 1993

11. The concept of “neutral” and balance within the three spinal subsystems: passive, active and neural. Component dysfunction in one subsystem forces compensation by another subsystem.

    Panjabi MM: The stabilizing system of the spine. Part 1: Function, dysfunction, adaptation and enhancement. Journal of Spinal Disorders 5: pp. 383-389

12. The neutral zone is a region of intervertebral motion around the neutral posture where little resistance is offered by the passive spinal column…neutral correlates well with other indicators of instability…and has been found to increase with injury and possibly degeneration, to decrease with muscle force increase and to decrease with instrumented fixation.

    Panjabi MM: The stabilization system of the spine. Part II: Neutral zone and instability hypothesis. Journal of Spinal Disorders 5: pp. 390-397, 1992

Imbalance Precipitates Pathology and Dysfunction

13. The intradiscal pressure increased as flexion motion increased. A greater increase was seen at the L4-5 level than the L3-4 level.

    Weinhoffer S, Guyer R, et al: Intradiscal pressure measurements above an inter-body fusion. Spine 20: pp.526-531, 1995

14. Patients with Duchenne Muscular Dystrophy usually develop progressive spinal deformities which lead to problems including poor sitting balance, pain…and respiratory compromise.

    Takenori O, et al: Longitudinal study of spinal deformity in Duchenne Muscular Dystrophy. Journal of Pediatric Orthopedics 13: pp. 478-488, 1993

15. We can conclude that vertebral body pressures vary with position and that these pressures are greatest in the sitting position – the posture usually associated with increased low back pain. By elevating the pressure, we can cause low back pain.

    Esses S, Moro J: Intraosseus vertebral body pressures. Spine 17: pp. 155-159, 1992

16. Optimization of the surgical results on low back pain requires change in the factors that led to the patient’s surgical disorder. The factors are poor posture, improper body mechanics, weakness, abusive activities and

general lack of understanding of back health care. Education and exercise will change these factors and help prevent the epidemic of failed multi-operated patients with back problems.

White A: Low Back Pain. Chapter 44: pp. 416-419

17. Patients with kyphosis and rounded shoulders had an increased incidence of cervical, inter-scapular, and headache pain. This study suggests a relationship between the presence of some postural abnormalities and the incidence of pain.

    Griegel-Morris P, et al: Incidence of common postural abnormalities in the cervical, shoulder and thoracic regions and their association with pain in two age groups of healthy subjects. PT 72: pp. 425-430, 1992

18. Kyphosis, initially modest, progresses to the well-recognized dowager's hump of the post-menopausal osteoporotic woman. Kyphosis is not only associated with relatively altered vertebral body shape (wedging), but also with reduced bone density and fitness, as well as decreased muscle strength, and is associated with reduced survival. We found an unexpectedly high (35%) incidence of kyphosis in a healthy sample of well women 20 to 64 years of age…Among the post-menopausal women, normal postural I/K was inversely correlated with age. Upright (posed) postural kyphosis was not related to age, nor was normal postural I/K in the pre-menopausal woman.

    There was no direct relationship demonstrated between current calcium consumption and I/K. Similarly, neither estrogen levels nor follicle-stimulating hormone levels were related to current posture. Women with satisfactory exercise habits had significantly lower I/K. As normal posture becomes kyphotic, an individual can no longer straighten the vertebral column.

    Cutler W, et al: Prevalence of kyphosis in a healthy sample of pre- and post-menopausal women. Am J Phys Med Rehabil 72: pp. 219-225, 1993

19. The mean thoracic kyphosis increased and the mean lumbar lordosis decreased with age in both sexes, but these changes were not constant. Thoracic kyphosis was most pronounced at a mean age of 12.8 years and lumbar lordosis was least pronounced at a mean age of 13.8 years. In accordance with the literature, the wide individual variation found in this study for both thoracic kyphosis and lumbar lordosis during the pubertal growth period was mainly physiologic.

    Nissinen M: Spinal posture during pubertal growth. Acta Paediatr 84: pp. 308-312, 1995

20. Forward head posture is one postural adaptation likely related to occupations and activities requiring anterior head positions for prolonged periods.

    Damell M: A proposed chronology of events for forward head posture. J Craniomandibular Pract 1: pp. 50-54, 1983

21. Signs and symptoms such as pain in the lumbar spine and pelvis are correlated with forward head posture.

    Rocabado M: Musculoskeletal approach to maxillofacial pain. Philadelphia: Lippincott, 1991: 136-138, 190-191.

22. In sitting posture…thoracic kyphosis showed a significant difference between groups; individuals with acute pain had an increased thoracic kyphosis compared with the control group…(In standing posture, found increased lordosis in the chronic group which is the opposite finding of other researchers i.e. Pope, Day and During)…postural parameters are significantly different between low back pain groups. However, based on this study, it cannot be stated whether poor posture leads to pain or precipitation of pain necessitates postural aberrations. It is surmised that both scenarios occur.

    Christie H, et al: Postural aberrations in low back pain. Arch Phys Med Rehabil. 76: p. 224, 1995

23. Mean values of postural parameters in the group of spondylolysis patients differ significantly from those in the group of healthy volunteers.

    During J, et al: Toward standards for postural characteristics of the lower back system in normal and pathologic conditions. Spine 10: pp. 83-87, 1985

24. Increased lumbar lordosis places increased stress on the pars interarticularis. Fatigue fractures of the pars can result in spondylolysis. There was a 50% incidence of symptomatic spondylolysis in 18 patients who had Scheuermann's kyphosis and an increased lordosis.

    Ogilvie B, Sherman J: Spondylolysis in Scheuermann's disease. Spine 12: pp. 251-253, 1987

25. Significant correlations were found between kyphosis and lordosis and between lordosis and sacral inclination, indicating that these curves tend to balance each other.

    Voutsinas S, MacEwen G: Sagittal profiles of the spine. Clin Ortho and Related Research 210: pp. 235-242, 1986

26. An inflatable wedge was used to support the lumbo-sacral curve of patients undergoing anesthesia and surgery in either the supine or the lithotomy position. Of the operative factors investigated, the presence of a wedge was the only one found to have a useful influence on the incidence of postoperative backache, which was reduced significantly from 38% to 8.5%.

    O'Donovan N, et al: Post-operative backache: the use of an inflatable wedge. Br. J. Anaesth. 58: pp.280-283, 1986

27. We suggest that lumbar degenerative kyphosis be included as one of the abnormal sagittal curvatures in which a kyphosis or a marked loss of lordosis is seen in the lumbar spine, caused by degenerative changes in middle-aged and elderly patients. One hundred and five patients were investigated, most of whom complained of low back pain, often with a lengthy history. They all walked in a forward bending posture, either all the time or only when exhausted. In x-ray, most cases showed a marked loss of the sacral inclination, as well as multiple disc narrowing and or vertebral wedging in the lumbar region. These subjects showed a definite weakness of the lumbar extensors compared to the flexors, and therefore a reversed ratio of extensor/flexor muscle power compared with normal controls and other types of spinal curvatures. Weakness of the lumbar extensors was clearly shown by isokinetic measurement and a marked atrophy of these muscles with fatty infiltration demonstrated by CT scanning.

    Takemitsu T, et al: Lumbar degenerative kyphosis. Spine 13: pp. 1317-1326, 1988

28. If lumbar lordosis is diminished sufficiently to create sagittal plane imbalance, a disabling symptom complex known as "flat back syndrome" may develop. This postural disorder is characterized by back pain, forward inclination of the trunk, and inability to stand erect.

    Symptoms include muscular pain in the upper back and lower cervical area, pain in the knees and inability to stand erect.

    Moe and Denis found that forward displacement of the trunk could be objectively measured by dropping a plumb line from the center of the body of the seventh cervical vertebrae and measuring the distance from the sacral promontory to this plumb line. This measurement averaged 10 cm in their patients. They considered normal to be less than 2 cm.

    The flat back condition is a "syndrome" and therefor represents a spectrum of etiologic and aggravating factors. Those factors that have been identified as being responsible for or contributory to the development of the flat-back syndrome are:

    - a- distraction instrumentation into the lower lumbar spine or sacrum
    - b- thoracolumbar kyphosis
    - c- pseudoarthosis with loss of sagittal plane correction
    - d- fixed thoracic hyperkyphosis
    - e- hip flexion contractures

    Patients with hyper-extendable hips can often compensate for loss of lumbar lordosis. As noted by Hasday et al, hip hyperextension is the favored compensatory mechanism for loss of lumbar lordosis. This concept is further exemplified in patients with weakness of hip extensors who compensate poorly for loss of lumbar lordosis because of the diminished ability to hyperextend the hips. Another compensatory mechanism for loss of lumbar lordosis is extension of the thoracic spine.

Because of the wide range of values for kyphosis and lordosis in normal individuals, there is no absolute value that can be considered normal. It is the overall sagittal plane balance that is important. The most useful radiographic measurement to evaluate this sagittal plane balance is the full length standing lateral radiograph with the knees extended. On this view, the C7-S1 measurement should fall within 2 cm of the anterior aspect of the sacrum.

La Grone A: Loss of lumbar lordosis: A complication of spinal fusion for scoliosis. Orthopedic Clinics of North America 19: pp. 383-393, 1988

29. It has been demonstrated by Krag, et al that metal pellets placed within the disc and subjected to repetitive flexion to neutral maneuvers, the pellets will slowly migrate posteriorly. In addition, Adams and Hutton have demonstrated that flexion compression loads the segments and causes disc deterioration with gradual nuclear extrusion. They can demonstrate this with posterior [deforming] of the nucleus. Gradually, fissures appeared in the posterior annular lamellae with the nuclear pulp migrating into these.

    It has been demonstrated that clinically, there is a high degree of response to this treatment (repeated extension exercises)…better than flexion, traction and back school.

    In summary, what is the answer to the question of where is the pain coming from in the chronic low back pain patient? I believe its source, ultimately, is in the disc. Basic studies and clinical experience suggest that mechanical therapy is the most rational approach to relief of the painful condition. Avoidance of habituation to pain and inactivity is largely a societal question rather than a medical question. In the future we expect a more precise definition of disc abnormality, best seen by a CT scan.

    Mooney V: Where is the pain coming from? Presidential address, International Society for the study of the lumbar spine, Dallas 1986. Spine 12: pp. 754-759, 1987

30. Lumbar flat back syndrome produces pain and cosmetic abnormalities and difficulty in locomotion. Thoracolumbar sagittal plane imbalance may occur after unsuccessful surgery for idiopathic or congenital deformities. The primary resulting deformity is kyphosis, as is the lumbar flat back syndrome.

    Shufflebarger H, Clark C: Thoracolumbar osteotomy for post-surgical sagittal balance. Spine 17: pp. 287-290, 1992

31. Degenerative changes in the vertebral discs, the facet joint and even the interspinous ligaments, are probably caused by pressure damage…protection of the disks and facet joints from prolonged continuous loading is essential for the prevention of continuing degeneration.

    Beckors L, Bekaert J: Role of lordosis. Acta Orthopaedica Belgica 57: pp.198-202, 1991

32. Thoracic kyphosis, a primary deformity of the osteoporotic spine, appeared compensated by the lumbar spine, sacroiliac joint, hip joint and knee joint, respectively. Low back pain was highly associated with decreased lumbar lordosis and increased sacro-pelvic angle, suggesting that the sacroiliac joint was one of the cause of low back pain.

    Itoi F: Roentgenographic analysis of posture in spinal osteoporosis. Spine 16: pp. 750-756, 1991

33. The average increase in height was 30 mm (after 8 hours of rest). 40% of the height increase took place in the lumbar spine without change in the depth of the lordosis, and 40% took place in the thoracic curve with a decrease in the kyphosis. The remaining 20% was not located but cervical was not evaluated.

    Wing P, et al: Diurnal changes in the profile shape and range of motion of the back. Spine 17: pp. 762-766, 1992

34. Mildly loaded joints at their extreme ROM experience discomfort which is linear for the first 4 minutes. Smaller joints are 6 times more sensitive than larger joints, initial release discomfort is often greater than loaded discomfort. The results imply that static work postures should also be analyzed with respect to joint position.

    Harms-Ringdahl K, et al: Discomfort and pain from loaded joint structures. Scan J Rehab Med 15: pp. 205-211, 1983

35. The higher contact pressures with disc narrowing and in extension could possibly damage the facet joints. Lewin found a link between osteoarthritis of the facet joints and osteophytic lipping of the vertebral bodies. In our

experience, lipping of the vertebral body is usually accompanied by disc narrowing. Many patients with disc space narrowing have either reduced extension or pain in extension or both.

Dunlop R, et al: Disc space narrowing and the lumbar facet joints. J Bone and Joint Surg 66-B: pp. 706-710, 1984

36. Kyphosis greater than 50 degrees correlated with increasing pain and decreasing forced vital capacity. Reduction in forced vital capacity also correlated with muscle rigidity.

    Jackson R, et al: Coronal and sagittal plane spinal deformities correlating with back pain and pulmonary function in adult idiopathic scoliosis. Spine 14: pp. 1391-1397, 1989

37. Thoracic kyphosis was increased and lumbar lordosis was reduced in fracture subjects who also had reduced trunk extension, reduced thoracic and lumbar sagittal motion, reduced functional reach and reduced mobility skills.

    Lyles K, et al: Association of osteoporotic vertebral compression fractures with impaired function status. Amer Journal of Medicine 94: pp, 595-601, 1993

38. Complaints of back pain in the elderly range from 20 to 38%. Back pain is the third most frequently mentioned complaint and the most commonly mentioned musculoskeletal symptom…low back pain was the most frequently mentioned source of pain and was reported by 40% of residents who reported pain.

    Mobly P, Herr K: Back pain in the elderly. Geriatric Nursing March/April: pp. 110-116, 1992

Improved Sagittal Balance is Associated Reduction In Symptoms

39. These data indicate that limited ROM lumbar extension training through 36 degree ROM is effective for developing strength through 72 degrees of lumbar extension.

    Graves J, et al: Limited range of motion lumbar extension strength training. Medicine and Science in Sports and Exercise 24: pp. 128-133, 1992

40. Women with mammary hypertrophy usually have a number of complaints relating to the skeletal system…heavy breasts change the center of gravity by increasing cervical lordosis and greatly increasing muscle tension in the extensor muscles of the neck. This shift not only is fatiguing but also compresses the soft tissues and eventually the intervertebral disks [causing] osteophyte formation and [increasing] the potential for spondylosis…Poor posture may reflect a conscious effort to conceal hypertrophic breasts [thus increasing] normal spinal curvatures. As the center of gravity becomes more abnormal so does posture…[which spontaneously improves] after reduction…[if not, patients should receive help with] muscle re-education and postural exercises.

    Letterman G, Schurter M: The effects of mammary hypertrophy on the skeletal system. Plastic Surgical Service of the George Washington University School of Medicine and Health Sciences, Washington DC. Little, Brown and Company, pp. 425-431, 1980

41. Postural kyphosis is much more common than Scheuermann’s disease but the clinical presentation is similar. In the postural form, however, the degree of kyphosis is usually less, the spine is much more supple, and there is no wedging of the vertebral bodies. Treatment usually consists of an exercise regimen. If the deformity becomes rigid or progresses, bracing may be instituted: results are usually good.

    Herndon W: Spinal deformities in children. Postgraduate Medicine 76; pp. 67-76, 1984

42. We hypothesize that this inexpensive, unobtrusive device promotes improvement in posture and reduces back pain either by acting as a proprioceptive reinforce or by producing a force posteriorly below the inferior angles of the scapulae and thus decreasing the anterior compressive forces that are commonly exerted on the spine. Among the 23 patients who reported substantial back pain before use of the support, relief of the pain was “significant” in 17 and minimal in 6. Nineteen noted improvement in their posture.

    Kaplan R, Sinaki M: Posture training support: Preliminary report on a series of patients with diminished symptomatic complications of osteoporosis. Mayo Clin Proc 68: pp. 1171-1176, 1993

43. Chow and Harrison reported that subjects who were physically active had less kyphosis than did those who were involved in minimal physical activity. Itoi and Sinaki also reported a significant negative correlation between back extensor strength and thoracic kyphosis in healthy estrogen-deficient women. Increasing the back extensor strength in healthy estrogen-deficient women helps decrease thoracic kyphosis.

    Itoi E, Sinaki M: Effect of back strengthening exercise on posture in healthy women 49 to 65 years of age. Mayo Clin Proc 69, pp. 1054-1059, 1994

44. A specific exercise program has been shown to increase height and back strength and decrease kyphosis length in osteoporotic women with back pain while control subjects had increased perception of ADL difficulty. The exercise group expressed a sense of "standing taller" and were pleased with the objective changes shown at the end of the study.

    Lindsey C, et al: Evaluation of the effects of exercise on posture, back strength, pain and mood in post-menopausal women with osteoporosis and back pain. Unpublished report, University of Connecticut Health Center, Department of Rehabilitation, Farmington, CT 1995

45. There was a considerable effect (10-24%) of lumbar curvature on lever arm lengths for the back extensor muscles. The change in leverage will affect the need for extensor muscle force and thus the magnitude of compression in the lumbar spine in loading situations such as lifting.

    Tveit P, et al: Erector spinae lever arm length variations with changes in spinal curvature. Spine 19: pp. 199-204, 1994

46. A high percentage of patients were found to have faulty inner ear functioning leading to inefficient muscular control of balance, and erect posture.

    The prevalence of fibromyalgia in more than 50% of the patients in this series suggests areas for further research.

    Chester J: Whiplash postural control and the inner ear. Spine 16, pp. 716-720, 1991

47. In 18 kyphosis patients, an average of 13 degrees of correction was accomplished with stimulation of the paraspinal musculature.

    Axelgard J, et al: Correction of spinal curvatures by transcutaneous electrical muscle stimulation. Spine 8: pp. 463-481, 1983