

C A S E S T U D Y

A Three-Paradigm Treatment Model Using Soft Tissue Mobilization and Guided Movement-Awareness Techniques for a Patient With Chronic low Back Pain: A Case Study

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Over the last two decades, interest in soft tissue mobilization (7,19,22,36,41) and movement reeducation procedures (4,50,54) for the treatment of idiopathic low back pain has dramatically increased. One reason for this interest may relate to the number of cases attributed to idiopathic low back pain. It has been estimated that as high as 80% of all patients with low back dysfunction exhibit no other known pathological antecedents (eg., disc problems or degenerative joint disease) (60). Another factor may relate to the chronic and recurrent nature of many of these low back cases and, in turn, the frustration they provide physical therapists and other manual therapy practitioners in designing successful treatment protocols (33).

From a historical perspective, many of the current soft tissue approaches utilized by physical therapists have been adapted from the traditional osteopathic manipulations founded by Still (12) and other early osteopaths (12,21) and the techniques developed by Rolf (47,48). Similarly, some of the popular movement-awareness approaches now being studied have been influenced by and derived from the earlier work of Alexander (1,11,23) and his student, Feldenkrais (15,50).

It is not uncommon for physical therapists to report difficulty in treating certain subjects with chronic idiopathic low back pain. The purpose of this case study is to present a three-paradigm model of intervention that may be adapted to the treatment of such cases. The model consists of: 1) relaxation paradigm, consisting of pain modulation procedures; 2) corrective paradigm, involving manual techniques and exercise to correct specific faulty biomechanical alignment(s) (eg., pelvic asymmetry); and 3) integrative paradigm, utilizing guided movement/mobilization techniques for improving the subject's overall pattern of posture and movement. The case study of a young adult with chronic low back pain correlated with unilateral innominate bone rotation is presented to illustrate the three-paradigm approach. Over six sessions, the subject received a corrective (sessions 1–3) and an integrative treatment protocol (sessions 4–6) consisting of Rolf's method of soft tissue mobilization and Alexander's system of guided movement-awareness techniques. Before and after each session and after a 4-week follow-up, the subject was assessed for sacroiliac joint pain using a compression technique, anterior rotation of the innominate bones, pelvic angle in the standing position, and vagal tone as determined from heart rate variability. The therapist's visual analysis of sit-to-stand movement and the subject's self-reports of pain were noted. A corrective paradigm protocol of soft tissue mobilization and exercise was unsuccessful in eliminating the subject's assessed anterior rotation of the innominate bone and associated low back pain for more than J-2 days posttreatment. Only after the implementation of a third paradigm movement/mobilization protocol did the subject begin to exhibit sustained improvement through a 4-week follow-up. Interpretations of the results, appropriate selection of corrective and integrative protocols, and physiological mechanisms are discussed.

Key Words: guided movement-awareness techniques, sacroiliac joint dysfunction, soft tissue mobilization

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Underlying Assumptions of Traditional Soft Tissue Mobilization and Movement Systems

An underlying assumption of these soft tissue manual and movement-awareness techniques is that

faulty biomechanical alignment and myofascial imbalance in one region will create compensations in distant anatomical segments (7,26,48). The net effect of these compensations will, in turn, be manifested by dysfunctional movement patterns in sit-

to-stand, walking, squatting, and other gravity-dependent activities (4, 25,41,48). Faulty biomechanical alignment is defined as a biomechanical deviation that is presumed to be a major factor in producing the patient's physical condition and pain (47,48). Myofascial imbalance refers to inappropriate length and/or tension in muscles and their fascial/tendinous attachments that is hypothesized to be responsible for the biomechanical deviation in question (28,48,51,55). Dysfunctional movement is defined as a faulty pattern of alignment and neuromuscular activity that is functionally and energetically inefficient (26,48).

Rolf (47) and Gordon (19) have proposed the use of soft tissue mobilization and guided movement techniques for treating low back pain conditions that have been correlated with pelvic asymmetry in the sagittal plane. They assume that sacroiliac joint dysfunction, including unilateral and bilateral rotations of the innominate bones, is a major contributing factor to biomechanically induced low back pain (5,9). However, critics doubt the role that sacroiliac joint dysfunction and correlated innominate bone asymmetry plays in producing low back symptoms. They believe that so-called sacroiliac symptoms are discogenic in origin (21,38) or the result of back extensor muscles transmitting stress to the sacroiliac joint (35,38,58).

Rolf (47) and Sultan (55) have further proposed that anterior rotations of the innominate bones are associated with increased sympathetic activity and a concurrent reduction of parasympathetic tone. They maintain that an increase in parasympathetic tone is associated with a relaxed, nurturing physiological state, whereas increased sympathetic tone is correlated with a heightened arousal "fight-flight" condition (31,32). They also maintain that a reciprocal relation exists between the parasympathetic and sympathetic divisions: when one branch is activated, the

other branch is inhibited to maximize the response of the stimulated branch (8,31,32). To date, this proposed link between autonomic output and pelvic asymmetry associated with low back pain lacks scientific substantiation. However, Cottingham et al (8) found some support for this position in a study of healthy subjects. A control and mobilization group was preselected for exhibiting excessive standing pelvic tilt ($>9^\circ$ in the sagittal plane) as determined by an inclinometer (6,59). Parasympathetic cardiac vagal tone was assessed from respiratory sinus arrhythmia, a variability in the heart rate pattern that is defined as the periodic increase and decrease in heart rate normally associated with respiration (3). Those in the mobilization group, who received a soft tissue mobilization session based on Rolfs method, demonstrated a decrease in standing pelvic angle and an increase in vagal tone immediately following the treatment and in a 24hour follow-up assessment.

Three-Paradigm Model of Treatment Intervention

To better account for the above-mentioned assumptions that seem inherent in integrative manual and movement systems, Maitland (33) and Maitland and Sultan (34) have recently developed a three-paradigm model for treatment protocols. At the first level, the relaxation paradigm, the therapist attends to the alleviation of pain and other symptoms that might interfere with the administration of manual therapy techniques and other procedures.

At the second level, the corrective paradigm, the practitioner attempts to restore regional faulty biomechanical alignment, myofascial imbalance, and restricted joint motions that have been assessed as contributing factors in producing the subject's signs and symptoms. Soft tissue mobilization may be applied

for shortened or excessively lengthened muscle groups as well as for altering resting muscle tone. Exercise, joint mobilization, movement reeducation, and stretching may also be introduced in the second, corrective paradigm approach.

At the third level, the integrative paradigm, the practitioner attempts to assess and treat faulty positional alignment and dysfunctional movement as a unified pattern. The goal of the integrative paradigm is to develop postural and movement patterns that are more neuromuscularly and functionally efficient. The third paradigm is typically implemented when the relaxation and corrective approaches have not been successful in eliminating the subject's signs and symptoms. Note that protocols utilizing the integrative paradigm are not mutually exclusive or in opposition to protocols that use the first and second paradigms. For example, a third paradigm approach may incorporate pain management methods and corrective strategies from the first two levels into the initial stages of treatment.

The purpose of presenting this case study is to illustrate how a three-paradigm model of therapeutic intervention can be adapted for the treatment of a young adult with chronic low back pain correlated with pelvic asymmetry. The case, selected from the author's physical therapy practice (JTC), utilizes Rolf's method of soft tissue manipulation and Alexander's system of guided movement in the protocol. These nonconventional treatment methods were chosen for their emphasis on an integrative approach to treatment of low back conditions as well as for their historical influence on current manual therapy techniques (4,19,48). The relative efficacy of these methods when compared with more conventional techniques of exercise, mobilization, and postural correction are beyond the scope of this case study.

HISTORY

A 19-year-old, female college student was referred to physical therapy by her primary physician for recurrent left-sided low back pain. Her chief complaint was a dull aching pain in the left low back and buttock region. She also reported intermittent radiating symptoms in the posterior aspect of her left thigh (ie., two or three times a week with each episode, 12-24 hours in duration). She did not believe that her symptoms varied with the time of day. Her symptoms increased during forward bending and prolonged sitting or standing. When the subject bent forward with knees straight to tie her shoe, she stated that the buttock pain increased immediately. The sitting and standing pain took about 30 minutes for onset, with occasional radiating, aching pain down the lateral aspect of her left thigh to the knee. The subject's symptoms were previously relieved for short periods of time (1-5 days) with rest, full body massage, and chiropractic adjustments. The subject first remembered experiencing low back pain about 2 years ago and that it was gradual in onset. She reported her left low back pain as being constant for the last year.

PHYSICAL EXAMINATION

The subject was observed as she moved from sitting in a straight chair to a standing position. As the subject prepared and initiated this movement, the head moved backward and down into excessive hyperextension with movement appearing to be primarily in the upper cervical area; the cervical and lumbar lordotic curvatures increased slightly; and the anterior tilt of the pelvis in the sagittal plane increased (Figure 1A). Concurrently, her scapulae appeared protracted and elevated.

Observation of the subject's static standing posture from the lateral and frontal views revealed excessive lordo-

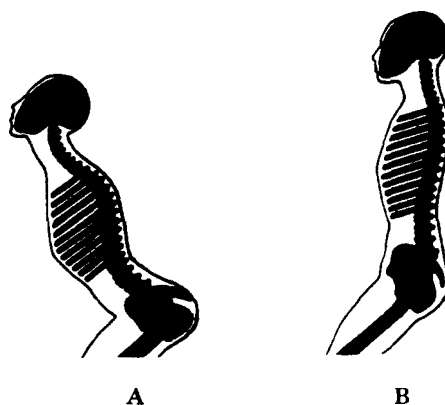


FIGURE 1. A schematic representation of the subject's axial alignment during unsupported and unguided movement from an erect sitting to an erect standing position. A) Subject's alignment pattern during the initial evaluation. B) Subject's alignment after treatment session 5. Note in (A) the increased extension at the atlanto-occipital joint and the enhanced cervical and lumbar lordosis. In (B), this pattern of excessive extension is dramatically reduced, and the torso's angle of ascension in relation to the vertical plane is also decreased. [From Cottingham (7), reprinted with permission].

sis in the cervical and lumbar spine regions and anterior rotation of the pelvis similar to that noted during her movement from a sitting to a standing position. Below the pelvis, the patient's base of support appeared relatively symmetrical with no rotations or misalignments observed in the lower extremities. Also in standing, a moderate functional lumbar scoliosis, concave to the left, was noted. Active lumbar motions were then visually assessed in standing. Forward bending appeared full with the subject able to touch her toes with both knees fully extended and without pain. During forward bending, the internal curvature disappeared and normal lumbar flattening occurred before the pelvic rotation was observed. Backward bending appeared to be within normal limits and pain free. In side bending left, the patient could reach her fingertips 3 cm below the lateral joint line of the knee. In side bending right, her fingertips could only reach the lateral aspect of the thigh 1 cm above the joint line of the knee. Both sidebending motions were pain free. Note that

prior to sidebending, the patient's left shoulder was observed to be slightly lower than the right shoulder.

With the subject standing, palpation of the posterior superior iliac spines revealed the left to be superior to the right, and this difference increased when she bent forward. She also reported left-sided buttock pain at the end range of this movement. This finding is indicative of a positive standing flexion test, where there is purportedly limited sacroiliac joint motion on the elevated and painful side (5,46). The standing flexion test, however, has shown poor intertester reliability (38,46).

While the subject was sitting in a straight back chair with feet on the floor, palpation revealed the left posterior superior iliac spine to be higher than the right. This relationship between the right and left posterior superior iliac spines remained unchanged during forward bending. Visual assessment of the subject's trunk rotation while she was sitting appeared to be symmetrical, right to left, and pain free. Palpation of the medial border of the left posterior superior iliac spine in sitting and standing provoked a localized aching pain; this pain had greater intensity in standing. With the patient in a supine position, an active straight leg raise was visually observed to be over 90° of hip flexion in both lower extremities and did not provoke pain. During the straight leg raise, the pelvis was observed to rotate posteriorly and the lumbar lordosis flattened. Further, straight leg raises with ankle dorsiflexion at the end of the range did not reproduce the patient's pain in either leg.

The subject's respiration pattern was assessed while she was in a supine position. Her breathing appeared to be dominated by diaphragmatic movement with minimal chest expansion during inspiration and minimal contraction of chest muscles during expiration (2,48).

The sacroiliac compression/distraction test was administered to the

right and left anterior iliac spines while the patient was in side-lying positions (57). This test is one of the few assessments of sacroiliac joint dysfunction that has demonstrated high intertester reliability (46). The sacroiliac compression test reproduced the patient's left low back pain (dull ache) in the area of the left posterior superior iliac spine. The sacroiliac distraction test did not reproduce any low back pain. With the subject in a supine position, the same aching pain in the area of the left posterior superior iliac spine was provoked with the Patrick test by flexing the subject's left hip to 90° and then externally rotating and abducting the hip. The Patrick test, however, has not shown high intertester reliability (38,46).

With the subject in a right side-lying position, an innominate bone rotary test for anterior rotation was performed with the therapist's palms on the left posterior iliac crest and ischial tuberosity. This test produced a dull aching pain around the left posterior superior iliac spine. When this test was administered to the right innominate bone with the subject in a left side-lying position, no low back pain was reproduced. Also, with the subject in a side-lying position and with the therapist placing one hand over the anterior superior iliac spine and one hand over the ischial tuberosity, an innominate bone rotary test for posterior rotation was administered. This test was negative bilaterally for the subject's low back pain. Wadsworth (57) has proposed that manually rotating the innominate bone further into its rotation will produce a subject's symptoms. The reliability and validity of these two innominate bone rotary tests has not been demonstrated.

Leg length was assessed by comparing the positions of the medial malleoli in supine and long sitting positions. In a supine position, the left medial malleolus was extended 2 cm distal to the right, whereas in a long sitting position, the levels of the

	Initial Evaluation	4-Week Follow-Up
Hip extension		
Right	16.0	17.0
Left	6.0	17.0
Hip external rotation		
Right	40.0	41.0
Left	31.0	38.0
Hip abduction		
Right	28.0	27.0
Left	20.0	23.0

TABLE 1. Summary of passive range of motion for hip extension, external rotation, and abduction assessed during the initial evaluation and the 4-week follow-up.

medial malleoli were equal. The validity and intertester reliability of these tests has been questioned by investigators (5,38,46).

The patellar and calcaneal deep tendon reflexes were brisk and bilaterally symmetrical. Manual muscle tests, as described by Kendall and McCreary (28), revealed normal muscle grades for hip flexors, hip extensors, hip adductors, lower abdominals, quadriceps femoris, ankle dorsiflexors/plantar flexors, and extensor hallucis longus muscles. With the subject in a prone position, posterior-anterior pressure was applied to each spinous process of the lumbar vertebra and no pain was produced.

With the subject in a prone position with the tested lower extremity in knee extension and the pelvis stabilized by the therapist to prevent anterior pelvic tilt, a single goniometric measurement of passive range of motion for hip extension revealed left hip extension to be limited by 10° compared with the right (Table 1) (37). This 10° difference between right and left hip extension was also found when the tested lower extremity was placed in full knee flexion, suggesting a shortened left iliopsoas rather than rectus femoris muscle (49). With the subject in a sitting position and the distal end of the femur stabilized by the practitioner to prevent hip abduction and hip flexion, a single goniometric assessment for

passive range of motion for external hip rotation showed the left to be 9° less than the right (37). With the subject in a supine position and the pelvis stabilized by the therapist to prevent lateral tilting and rotation, a single goniometric measurement for passive range of hip abduction indicated the left to be 8° less than the right (37).

Measurement of Pelvic Angle

Pelvic angle in the standing position was then measured with an inclinometer consisting of a universal protractor and bar clamp caliper (6,8,59). This technique for assessing pelvic angle has demonstrated high intertester (16-18) and intratester (17,18) reliability, although the validity of this method compared with radiographs was poor (18). The subject was told to assume an erect standing posture with weight distributed evenly, feet parallel, and the medial malleoli approximately 10-18 cm apart. The arms of the caliper were placed on the marked anterior superior iliac spine and posterior superior iliac spine. A single measurement of pelvic angle was read from the inclinometer to the nearest half degree. This procedure revealed a standing pelvic angle of 11.5° on the right and 14.5° on the left. Note that the greater pelvic angle assessed for the left innominate bone by 3° appears substantial compared with a group of 32 healthy young adult subjects assessed for standing pelvic angle, bilaterally (8). The healthy subjects demonstrated a mean pelvic angle of 12.1° with a standard error of 0.47.

Measurement of Vagal Tone

Parasympathetic activity was then assessed from a measure of beat-to-beat variability in the heart rate, respiratory sinus arrhythmia, with a Vagal Tone Monitor (Delta Biometrics, Inc., Bethesda, MD) (3,8,44). Experimental investigations have demon-

strated that respiratory sinus arrhythmia is mediated by the vagal innervation to the heart (3,29,42). Studies involving pharmacological and electrophysiological manipulations have demonstrated that the amplitude of respiratory sinus arrhythmia is a reliable and valid estimate of cardiac parasympathetic activity or vagal tone (3,8,43,44). The subject was positioned in supine with electrodes placed on the ventral surface of the wrists. Her electrocardiogram activity was monitored for a 2- to 4-minute period by an electrocardiogram amplifier (Scope Service, Inc., Urbana, IL). The output of the amplifier was input to the Vagal Tone Monitor for on-line analysis of heart rate and vagal tone (3,8). Respiratory sinus arrhythmia amplitude or vagal tone is expressed in natural logarithmic units on a scale of 1-10 and was determined to be 3.9 units at this testing. Note that this value is relatively low compared with vagal tone values found in a study of 32 healthy young adults who exhibited a mean vagal tone of 5.8 with a standard error of 0.2 (8).

ASSESSMENT

First Paradigm Assessment

Regarding the first paradigm, the subject's low back pain did not appear to interfere with the projected manual or movement treatments. Thus, first paradigm pain/relaxation modalities were not used. However, the subject's pain symptoms did change during the corrective and integrative treatment protocols. These changes are described in the treatment and results section.

Second Paradigm Assessment

Regarding the corrective second paradigm, the combined findings of: 1) a greater standing pelvic angle of the left innominate bone compared with the right, 2) the left lower extremity appearing longer than the

right while in the supine position, 3) the apparently equal lower extremity length in long sitting, 4) the reproduction of low back pain using the innominate bone rotary test for anterior rotation, and 5) the increased elevation of the left posterior superior iliac spine in standing and sitting positions suggests the presence of an anterior rotation of the left innominate bone (6,14,57). The alternative interpretation of a posterior rotation of the right innominate bone was dismissed based on the absence of pain during the bilateral innominate bone rotary test for posterior rotation (57) and the bilateral negative straight leg raise (5). The provocation of the subject's low back symptoms in the region of the left posterior superior iliac spine in response to the sacroiliac compression test, the Patrick test, the positive standing flexion test, and palpation of the medial aspect of the posterior superior iliac spine also suggests a problem at the sacroiliac joint (6,14,46,57).

However, due to the questionable reliability (6,38,46) and validity (38,46,58) found by investigators for most individual sacroiliac tests, actual sacroiliac joint dysfunction was still uncertain. Oldreive (38) believes these poor reliability and validity outcomes may be attributed to the lack of precise definitions for what constitutes a positive test result. One approach that has yielded good intertester reliability is to employ a combination of sacroiliac tests in which three of the four tests produce positive results (6).

In the subject's pre- and post-treatment assessments that follow, two tests of sacroiliac joint dysfunction were chosen that produced the subject's low back pain in the initial evaluation: sacroiliac compression test and innominate bone rotary test for anterior rotation. A third measurement, pelvic angle, was selected as an index of the relative anterior rotation of the innominate bones (6,8).

The limited passive range of motion found with goniometric measurements of left hip extension suggests shortening of the left iliopsoas muscle (28,51). The limited passive range of motion observed in abduction and external rotation of the left hip indicate possible shortening of the left hip adductor musculature. The restricted trunk motion identified in side bending to the right as well as the visually observed lumbar scoliosis, concave to the left, have been proposed to be correlated with shortened lateral trunk and hip muscles (28,47). Specifically, a shortened quadratus lumborum and the thigh adductors on the left side (28,47) and a shortened gluteus medius on the right have been implicated as possible components for this configuration of restricted sidebending and lumbar scoliosis (28).

Third Paradigm Assessment

In terms of the integrative third paradigm, the alignment of the body's major anatomical segments during static postures and movement is the primary component. Heavy emphasis was placed on visual observations of the subject as she moved from a sitting to a standing position, since this activity is frequently modified in individuals who have orthopaedic dysfunctions (4,10,15,54). Unfortunately, the reliability and validity of these visual assessments are, as yet, unknown. The compensatory shifts noted in sit-to-stand movements, including the increase in head extension at the atlanto-occipital joints and the spinal secondary curves, were interpreted as a habitual, dysfunctional movement pattern that was functionally and energetically inefficient (Figure 1) (26,47). This dysfunctional motion was considered as a possible limitation to the efficacy of the corrective manual protocol in treating the assessed anterior rotation of the left innominate bone. Overall, her lower extremity base of support appeared adequate to maintain any po-

	Initial Evaluation	2nd Pre- treatment	2nd Post- treatment	3rd Pre- treatment	3rd Post- treatment	4th Pre- treatment	4th Post- treatment	5th Pre- treatment	5th Post- treatment	6th Pre- treatment	6th Post- treatment	4-Week Follow-Up
Sacroiliac compression test	(-) R (+) L	(+) L	(-) L	(+) L	(-) L	(+) L	(-) L	(+) L	(-) L	(-) L	(-) L	(-) L
Pelvic angle in the standing position												
Right	11.5	11.0	11.0	11.5	11.5	11.0	11.0	11.5	11.0	11.0	10.5	11.0
Left	14.0	15.0	11.5	14.5	12.0	15.0	11.0	14.0	11.0	11.5	11.5	11.5
Innominate bone anterior rotary test	(-) R (+) L	(+) L	(-) L	(+) L	(-) L			(+) L	(-) L	(-) L	(-) L	(-) L
Vagal tone	3.9	3.7	6.2	4.0	5.9	3.8	6.4	3.5	6.1	5.9	6.4	6.0

+ = Positive

- = Negative.

R = Right.

L = Left.

TABLE 2. Summary of results for sacroiliac compression test, pelvic angle in the standing position, innominate bone anterior rotary test, and vagal tone as assessed in the initial evaluation, pretreatments, posttreatments, and 4-week follow-up.

tential shifts in biomechanical alignment to the head, neck, torso, and pelvis that might result from an integrative manual protocol.

Interpreting the possible clinical significance of the subject's vagal tone assessment is speculative at this time. However, the subject's relatively low level of assessed vagal tone supports Rolf's (47) and Sultan's (55) contention that decreased parasympathetic activity is clinically correlated with pelvic asymmetry involving anterior rotation of the innominate bone(s) and low back pain. They further hypothesized that the depressed levels of parasympathetic tone will increase only after anterior rotation of the innominate bone(s) is corrected and the associated low back pain is diminished (8,417). To explore these purported relationships between autonomic activity and pelvic asymmetry correlated with low back pain, vagal tone was chosen as a fourth measurement for the pre- and post-treatment testings.

TREATMENT AND RESULTS

The subject was seen once every 7 days for six sessions, approximately 50 minutes for each treatment, except for the first session in which a 30-minute treatment followed the initial evaluation. The treatment protocol consisted of soft tissue mobilization based on Rolf's soft tissue man-

ual system (8,47,53) and guided movement-awareness derived from Alexander's method (1,4,26). The patient returned for a voluntary, follow-up assessment 4 weeks after completing her sixth and final session.

During the initial evaluation, before and after each subsequent session, and at the 4-week follow-up, the patient was assessed on the following four indices: sacroiliac compression test, rotary test for anterior rotation of the innominate bone, pelvic angle in the standing position, and vagal tone. Goniometric measurements of passive range of motion for abduction, external rotation, and extension of the hip were made only during the initial evaluation and the 4-week follow-up. Tables 1 and 2 summarize the results of these assessments. The patient's self-reports of low back pain and the therapist's visual observations of sit-to-stand motion were also noted during all the above-cited assessments.

Second Paradigm Treatment

Session 1 The goals of the second paradigm intervention focused on correcting the myofascial imbalances that seemed directly related to the anterior rotation of the left innominate bone and the associated pain in the left buttock.

The shortened iliacus portion of the left iliopsoas muscle was ad-

dressed in the first session. Because a substantial portion of the iliacus' origin is from the iliac fossa and its insertion is on the lesser trochanter, a shortened iliacus has been proposed to be a major factor in certain anterior rotations of the innominate bone (27,47). With the subject lying in a supine position with her hips and knees flexed and feet flat on the plinth, the left iliacus muscle was palpated with the therapist's right fingertips just superior to the inguinal ligament and medial to the iliac crest. The subject was instructed to tilt her pelvis in a posterior direction while the therapist gradually increased the fingertip pressure on the iliacus. The pelvis was stabilized in this position of posterior tilt with the practitioner's free left hand, while the subject slowly extended the left hip and left knee into isometric extension and held for 10 seconds (Figure 2).

With the goal of reducing the anterior rotation of the left innominate as well as the associated pain, the therapist instructed the subject in the following home exercise program (14,57). The subject was instructed to stand with the left foot flat on a table, the left hip and knee fully flexed, and the pelvis positioned in a posterior tilt. She then shifted her weight forward onto the left leg while pulling the left knee forward to her chest with her hands. The stretch was



FIGURE 2. Mobilization of the left *iliopsoas* myofascia above the inguinal ligament.

held for 30 seconds and slowly released and repeated five times. She was instructed to perform this exercise three times daily or as needed to reduce pain. No objective posttreatment assessments were made in session 1. The subject's low back pain was unchanged from that reported during the initial evaluation portion of the session.

Session 2 When the subject returned for her second treatment 1 week later, she described no change in her left-sided buttock pain. Her pretreatment assessments were comparable with the initial evaluation results (Table 2). The therapist's visual observation of the sit-to-stand movement was unchanged from the initial evaluation. The therapist and subject reviewed the home exercise that was recommended in session 1. The iliopsoas mobilizations were repeated as outlined in session 1. Following these maneuvers, the patient reported less aching pain over the left posterior superior iliac spine.

Shortness of the ipsilateral hip adductor musculature has been hypothesized to contribute to increased anterior rotation of the innominate bones (28,47). In addition, since all of these muscles adduct the hip and



FIGURE 3. Mobilization of the left *gracilis* myofascia below its origins on the ischiopubic ramus.

arguably assist in internal rotation, a shortness in the length of the adductor musculature might, correspondingly, be estimated from the limitation of motion in ipsilateral hip abduction and external rotation. A limitation in hip abduction and external rotation was identified during the initial evaluation of the subject (Table 1). To mobilize the left adductor muscles, the subject was positioned in a left side-lying position with the right hip and knee flexed to 90° and supported by a pillow. The fingertips of the therapist's right hand were placed just below the left superior ramus of the pubic bone along the origins of the pectineus and the left hand positioned on the right iliac crest to stabilize the pelvis. The subject was asked to tilt the pelvis in a posterior direction and hold that position for 15 seconds and then release. This procedure was repeated for the adductor brevis, longus, magnus, and gracilis muscles, consecutively (Figure 3).

The visually observed lumbar scoliosis, concave to the left, and the assessed restricted right side-bending implicate a possible shortened left



FIGURE 4. Mobilization of the left *quadratus lumborum* myofascia above its attachments on the posterior iliac crest.

quadratus lumborum muscle (28,47). To mobilize and stretch the left quadratus lumborum, the subject was placed in a right side-lying position with a pillow between the extended knees. The olecranon process of the therapist's left elbow was placed at the attachments of the left quadratus on the posterior part of the iliac crest (Figure 4). The subject was then instructed to tilt the pelvis in a posterior direction, extend the left hip and knee, and dorsiflex the ankle and to hold this position for 30 seconds.

Posttreatment assessments revealed the following changes from the initial evaluation and second session pretreatment testing: 1) sacroiliac compression test was negative for pain, 2) left innominate bone rotary test for anterior rotation was negative for pain, 3) standing pelvic angles were almost equal (right = 11.0° and left = 11.5°), and 4) vagal tone had increased substantially to 6.2 (Table 2). The subject stated that the dull ache in her left buttock region was nearly gone. Observations of her sit-to-stand motion were still unchanged from the initial evaluation.

Session 3 When the subject returned for session 3, she reported being free of low back pain for 2 days after the second treatment. Two days after her second treatment, the subject's pain returned in the area of the left buttock with intensity levels similar to those experienced during the initial evaluation and second session pretreatment assessment. The objective measures taken at this pretreatment assessment were similar to those taken during the initial evaluation and second session pretest (Table 2). Observations of the subject's sit-to-stand movement and posture revealed no changes from the initial evaluation, second session pretest, or second session posttest.

The iliopsoas, the hip adductor muscles, and the quadratus lumborum soft tissue techniques were administered as described in the first and second sessions. The subject's home exercise was reviewed.

In the posttreatment assessment, the subject stated that her left low back pain had now disappeared, similar to the self-report given after the second posttreatment testing. The objective measures were also comparable with the results obtained in the second session posttreatment testing: sacroiliac compression test and innominate bone rotary test for anterior rotation were negative, right and left pelvic angles were nearly equal (right = 11.5° and left = 12.0°), and vagal tone was at 5.9 (Table 2). Visual observation of the sit-to-stand movement revealed no changes from the initial evaluation or the previous pre- or post-treatment assessments.

Third Paradigm Treatment

Session 4 During the fourth session, the subject again reported being free of her low back pain for 2 days after the third treatment, with her left aching buttock pain returning on the morning of the third day. The objective findings had also approximated the initial evaluation and previous pretreatment assessment

findings (Table 2). Visual observation of her sit-to-stand motion and standing and sitting postures was similar to the initial evaluation and previous pre- and post-treatment tests. Based on the findings obtained through the fourth pretreatment assessment, the therapist concluded that the correctional soft tissue mobilization strategies and home exercise alone did not appear to be sufficient to correct the anterior rotation of the innominate bone and relieve the patient's low back symptoms for a sustained time period (ie., more than 2-3 days). At this point, the therapist decided to implement an integrative intervention course of treatment, with priorities shifting to address the total pattern of segmental alignment in static positions and movement. This treatment focused on two aspects of the subject's pattern of segmental alignment: her respiratory motion (47,53) and her sit-to-stand movement (1,2, 25).

Visual observations of the subject's breathing made during the initial evaluation and during this session found her respiration pattern to be limited primarily to the diaphragm. To modify the patient's restricted breathing pattern, soft tissue mobilization was administered to the cranial attachments of the rectus abdominis muscle on the costal cartilages of the fifth, sixth, and seventh ribs (47,53). With the patient in a supine position and her knees flexed and feet flat on the plinth, the therapist's fingertips were placed along these attachments. Pressure through the fingertips was directed in a superior/posterior direction while the subject inhaled from diaphragm to chest (ie., by first starting inspiration in the abdominal area, then the epigastrium, and finally the chest). The pressure was then slightly increased as the subject reversed this sequence during expiration from chest to diaphragm (Figure 5). Following these mobilizations, visual observation revealed a more expansive breathing pattern with greater chest expansion in inspi-



FIGURE 5. Mobilization of the bilateral attachments of the rectus abdominis myofascia on the costal cartilages of the fifth, sixth, and seventh ribs.

ration and greater chest contraction in expiration.

As noted in the prior assessments of the preparation and initiation phases of her sit-to-stand movement, the subject was observed to hyperextend her head at the atlanto-occipital joints. The subject's atlanto-occipital hyperextension was first addressed by applying integrative soft tissue mobilization to the cervical extensor myofascia (47,53). With the subject in a supine position, fingertip pressure was applied along the cranial attachments of the splenius capitis and trapezius just inferior to the occiput as the subject nodded "yes." The muscles of the suboccipital group were mobilized in a similar manner (ie., the rectus capitis major/minor and superior capitis oblique attachments on the occiput).

Following the cervical extensor/suboccipital mobilizations, the subject was again observed in the sitting and standing positions and during her sit-to-stand movement. For the first time during her treatment, an overall improvement was noted in the subject's static alignment in the sitting and standing positions. There appeared to be a reduction in cervical



FIGURE 6. Guided movement-awareness technique for the sit-to-stand movement with the therapist's right thumb and fingers just distal to the attachments of the right and left sternocleidomastoid myofascia on the mastoid processes.

extension at the atlanto-occipital joints and diminished cervical and lumbar curvatures. However, when the subject initiated her sit-to-stand movement pattern, the previous configuration of exaggerated spinal extension returned.

To alter this persistent maladaptive movement sequence, guided movement-awareness techniques, as described by Jones (25), were introduced in the latter part of this session. The subject sat in a straight chair, assuming a comfortable erect posture. She was then assisted in positioning her pelvis in such a way that she could feel her ischial tuberosities make contact with the chair's surface while remaining in an erect sitting position. The therapist's right thumb and ring finger were placed just distal to the attachment of the left and right sternocleidomastoid muscles to the mastoid processes, respectively. The left hand was positioned on the patient's left anterior superior iliac spine (Figure 6). Just prior to initiating the sit-to-stand motion, the patient was instructed to equalize the practitioner's hand pressure by com-

ing into slight flexion at the atlanto-occipital joint without excessively increasing the tension in her neck flexor muscles. As the therapist guided the subject to an erect standing position, the patient's head was directed in an anterior and superior direction while the pelvis was concurrently guided posteriorly and inferiorly. From visual observation, the head appeared to go into further atlanto-occipital extension as the cervical lordosis increased, even though she reported that her neck felt as if it was lengthening. We believe it is common for a subject to exhibit such a faulty kinesthetic sense of body position during the early stages of guided movement training, where the subject initially exaggerates further into a faulty posture or movement in an attempt to correct it (1,11,23,26).

Again, in the fourth posttreatment assessment, the subject reported a disappearance of her left low back pain. Likewise, right and left pelvic angles were symmetrical at 11.0° , sacroiliac compression test was negative for pain, and vagal tone increased to 6.4 (Table 2). Visual observations of the sit-to-stand movement remained unchanged from the previous assessments.

Session 5 On the subject's arrival for the fifth session, she stated that her low back pain had once again returned to the left buttock area on the third day following her last treatment. She expressed concern about the lack of consistent improvement and compared her magnitude of pain to that reported in the initial evaluation and previous presession measurements. The objective pretreatment measurements again supported her self-report and were comparable with the initial evaluation and previous pretreatment assessments (Table 2). The visual observations of the sit-to-stand motion were also unchanged from prior assessments. However, as was first noted in the fourth session posttreatment assessment, the patient's static standing

and sitting postures were observed to exhibit less extension at the atlanto-occipital joints and less severe cervical and lumbar lordotic curves.

The entire fifth session was devoted to guided movement instruction as outlined in session 4. By the end of the fifth session, with the therapist's tactile and verbal cues, the patient was able to execute a head-neck-torso balance involving diminished extension at the atlanto-occipital joint and reduced lordotic curvature at the cervical and lumbar spine for the movements of sit-to-stand, stand-to-sit, and squatting. The subject was also instructed in home movement sequences for sit-to-stand, stand-to-sit, and squatting motions, with emphasis placed on maintaining the same dynamic head-neck-torso balance that she exhibited during the guided movements.

Objective assessments following the fifth session indicated that sacroiliac compression and the innominate bone rotary test for anterior rotation were once again negative for low back pain on the left, standing pelvic angles were equal at 11.0° , and vagal tone was at 6.1 (Table 2). The subject's comments were also consistent with these findings, reporting an absence of left aching buttock pain. For the first time since the initial evaluation, the therapist's visual analysis of the sit-to-stand movement indicated a substantial shift in the subject's spinal alignment (Figure 1B). A marked reduction was observed in extension at the atlanto-occipital joints and lordosis at the secondary spinal curves.

Session 6 For the first time during a pretreatment assessment, the subject reported that her left buttock pain did not return during the week following treatment. Also for the first time, the objective measures approximated their previous posttreatment levels: standing pelvic angle of 11.5° on the left and 11.0° on the right, negative sacroiliac compression test, negative innominate bone anterior rotary test, and a vagal tone level of

6.3 (Table 2). Likewise, the altered alignment pattern of decreased lordosis through the cervical and lumbar segments, first observed after the fifth session, was also evident from the therapist's observations of the subject's sit-to-stand movement.

This session, like the fifth, concentrated on the preparation and initiation stages of the sit-to-stand, stand-to-sit, and squatting movements. Emphasis was placed on therapist-guided movement of the head and neck. Specifically, the therapist attempted to facilitate movements that encouraged the patient to inhibit excessive extension at the atlanto-occipital joints and the joints of the middle cervical vertebrae. The subject then practiced these movements without the therapist's guidance. At the completion of the sixth and final treatment, the subject continued to execute sit-to-stand and other movements without reverting to the habitual pattern of exaggerated extension at the atlanto-occipital joint and at the cervical and lumbar curves that was first observed after session 5. The posttreatment findings for the sacroiliac compression test, standing pelvic angle, innominate bone rotary test for anterior rotation, and vagal tone were also comparable with the fifth session posttreatment and sixth session pretreatment assessments (Table 2).

4-week follow-up assessment The subject returned for a voluntary follow-up assessment 4 weeks after the sixth session (ie., 10 weeks after the initial evaluation) and reported no return of the left aching buttock pain during this period. The objective assessments were essentially unchanged from those reported in the fifth posttreatment, sixth pretreatment, and sixth posttreatment testings. Sacroiliac compression test and innominate bone anterior rotary test were negative for low back pain, standing pelvic angle was 11.0° on the right and 11.5° on the left, and vagal tone was at 6.0 (Table 2). Also, visual observa-

tion of the sit-to-stand movement was comparable with that noted in the fifth posttreatment, sixth pretreatment, and sixth posttreatment assessments, with diminished atlanto-occipital extension and decreased cervical and lumbar lordotic curvatures. Goniometric passive motion measurements for left hip extension, abduction, and external rotation all showed increases in the 4week follow-up compared with left hip motions noted in the initial evaluation (Table 1).

DISCUSSION

The combined results from the assessments taken through the fourth pretreatment testing suggest that the corrective paradigm treatment, consisting of soft tissue mobilizations to the iliopsoas, hip adductors, and quadratus lumborum and a home exercise, was only temporarily effective in derotating the left innominate bone, increasing parasympathetic tone, and relieving the subject's low back symptoms. This cyclic pattern of improvements found in the posttreatment measurements followed by a return to their initial evaluation levels in the next pretreatment assessment continued up to the sixth pretreatment measurement (Table 1).

What important change, then, did the subject undergo after the fifth session? Of the posttreatment assessments taken after the fifth session, only the shift observed in sit-to-stand alignment was a delineating indicator of when the subject began to exhibit a sustained reduction in anterior rotation of the innominate bone and associated low back pain as well as increased vagal tone.

There are at least three interpretations that could explain why this sudden shift in the subject's movement pattern is correlated with a prolonged improvement (4 weeks) in the subject's low back condition. First, the corrective protocol of the soft tissue manipulations and the

home exercise may have required this much time to correct and maintain the anterior derotation of the left innominate bone (14,19). Thus, the noted movement changes at the end of the fifth session are only coincidental to her long-term improvement. Second, the subject's low back pain spontaneously improved and neither the corrective mobilizations and exercise nor the integrative mobilization and guided-movement protocols are responsible for the subject's recovery (10,49). Both of these explanations are possible and cannot be completely dismissed.

A third interpretation that we believe best supports the data is that the guided movement produced a sustained shift in the preparation, initiation, and execution of the subject's sit-to-stand movement pattern and other voluntary motions. This shift toward more optimal movement, in turn, permitted the sustained improvements assessed through the 4week follow-up. Whether the soft tissue procedures and the home exercise of the corrective protocol were necessary prerequisite steps for the subsequent effectiveness of the integrative mobilization and guided-movement protocol cannot be determined from the data of this case study.

Vagal Tone and Clinical Assessment

It should be noted that the subject's level of parasympathetic activity, as assessed from vagal tone, consistently increased from the initial evaluation level when, correspondingly, the standing pelvic angle on the left side decreased and the two tests of sacroiliac joint dysfunction were negative for the production of left-sided low back pain (Table 2). Likewise, vagal tone measurements consistently decreased when the standing pelvic angle on the left side approximated the initial evaluation level and the two sacroiliac dysfunction tests were positive for the production of the low

back pain. Caution, however, should be exercised concerning the conclusiveness and sensitivity of these results. Unlike the prospective orientation of a single-case subject design, where extraneous variables are better controlled, this case study was selected from the author's physical therapy practice, retrospectively (13). Because of slight discrepancies in the assessment procedures and the recording of the data that naturally occurred in the clinical setting, the use of statistical procedures to better determine the sensitivity of vagal tone and standing pelvic tilt were not considered appropriate.

The possible role that vagal tone might play in clinical motor and sensory assessment must await further research. Recently, Sanko and Spalletta (52) have proposed that comparing normal to abnormal vagal tone responses, determined from heart rate variability, may be a valuable adjunct to sensory and motor system assessments. The assessment of vagal tone for musculoskeletal problems, especially those purportedly associated with autonomic dysfunction (eg., primary fibromyalgia and other chronic myofascial pain syndromes), may be useful areas of study (8,12,19). Recent neuroanatomical investigations have indicated that respiratory sinus arrhythmia (vagal tone) is under the primary control of the right vagus nerve through the nucleus ambiguus and, that through this nucleus, the right or "smart" vagus nerve has numerous higher cortical connections involved in the expression of human mobility, emotion, and communication (43). In light of these anatomical findings, we would note that vagal tone has been successfully used to assess central and peripheral nervous system function in several areas: a newborn's neurological status (44), autonomic stress (20), asthma (43), attention disorders (42), cognitive discrimination (42), and pain levels in infants (45).

Possible Physiological Mechanisms

The precise mechanism that might account for the apparent efficacy of the soft tissue mobilization and guided movement-awareness techniques is not known. Traditionally, speculations have focused on two mechanisms. First, connective tissue's ground substance has the ability to undergo plastic changes in response to heat produced by mechanical pressure and stretch (10,40,61). Oschman (39,40) has proposed that the resulting heat generated from the stretch and pressure of mobilization and guided movement alters connective tissue's molecular structure. This hypothesis receives some support from studies involving mechanical tissue testing and connective tissue remodeling (41,56,61).

The second mechanism involves the generation and modification of afferent information into the central nervous system through manual intervention (8,10). Proponents of this mechanism maintain that tactile pressure created by soft tissue mobilization and guided movement provides afferent input to the central nervous system that, in turn, alters efferent outflow to both the neuromuscular and the autonomic nervous systems (8,15,31). Stevens (54) and Jones (25) have speculated on such a mechanism that may account for the apparent efficacy of the guided movement techniques adapted for this subject's integrative treatment protocol. They proposed that optimal head-neck-torso balance (primary control) acts as an afferent stimulus to the central nervous system that inhibits habitual, inefficient motor responses (eg., elevation of the scapulae and excessive hyperextension of the cervical vertebrae during the initiation of the sit-to-stand movement). This inhibition of habitual motor responses assists the subject in consciously learning to facilitate antigravity and support reflexes, which then allows for more energetically efficient options of alignment in static posi-

tions and movement. Jones (25,26) provides support for this mechanism in a series of studies with healthy adult subjects who were assessed for differences in head-neck-torso alignment with multiple image photography, radiographs, and electromyography. He demonstrated that the subjects' sit-to-stand motion and other activities became better aligned and neuromuscularly more economical following the administration of experimenter-guided movement techniques to the head and neck.

Clinical Implications

We are not proposing, from the results of this case study, that all low back problems correlated with pelvic asymmetry must be approached through an extensive, integrative mobilization/movement protocol. As has been demonstrated, certain sacroiliac dysfunctions, with posterior or anterior rotations of the innominate bones, can be successfully treated with regional manual techniques, stretches, and exercise (5,14). However, the following two criteria appear useful in determining when a third paradigm manual/movement approach may be appropriate: 1) if the correction of the assessed biomechanical dysfunctions and relief of associated pain are not sustained over time (ie., 1-2 weeks), and 2) if the assessed movement and postural dysfunctions appear to interfere with the implementation of the second paradigm corrective or first paradigm relaxation treatments.

Further, other more conventional systems of manual therapy, exercise, and postural education may also be effectively applied through this model. For example, James (24) has combined neural tension mobilizations (30) with progressive exercise training (10,24) in corrective and integrative protocols with favorable results. DonTigny (14) has discussed the use of mobilizations and corrective exercises as well as modifying overall faulty postures and movement

in the treatment of anterior rotation of the innominate bones. Similarly, when corrective approaches have been ineffective for idiopathic low back pain correlated with pelvic asymmetry, the authors have successfully utilized third paradigm protocols of stretches (5) and sequential spinal stabilization exercises (10). Indeed, many physical therapists may currently incorporate comparable treatment strategies without necessarily distinguishing between the corrective and integrative aspects. Our purpose in presenting this three-paradigm model of intervention was to provide a concise theoretical framework that allows the practitioner to choose and design appropriate treatment protocols for chronic, recurrent low back pain. This model may be useful in developing protocols for other musculoskeletal dysfunctions as well. Finally, the successful outcome of a case study cannot be generalized as conclusive evidence for the efficacy of a specific method of treatment or a particular physiological mechanism of action. Case studies can, however, stimulate dialogue on these issues and encourage further research. Studies that compare the efficacy of the corrective and integrative protocols for the treatment of chronic low back problems on patient outcomes would be valuable.

SUMMARY

A case study involving a young adult subject with chronic low back pain was presented to explore and illustrate a three-paradigm model of successful treatment intervention: relaxation, corrective, and integrative. Soft tissue mobilization based on the methods of Rolf and guided movement adapted from the work of Alexander were used in the treatment protocol. Interpretations of the data, appropriate selection of corrective and integrative treatments, and possible mechanisms of action for the

guided movement/mobilization procedures were discussed. JOSPT

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