MANUAL THERAPY FOR THE THORAX

a
biomechanical
approach

Diane Lee

Manual Therapy For The Thorax

Acute and chronic thoracic pain is a common problem seen in physiotherapy practice today. There is very little anatomical, biomechanical or clinical research available for guidance in both evaluation and treatment planning. This text presents a biomechanical model of thoracic function which depends on the regional anatomy. The model is empirical and waits validation through research. In the meantime, it provides a solid base from which the practising clinician can evaluate and treat the painful thorax.

The anatomy, biomechanics, articular mobility and stability tests, mobilization procedures and stabilization exercises are a few of the topics covered in the text.

- **191 illustrations**
- **detailed descriptions of specific tests and mobilization techniques**

A very useful addiion to the practising clinician's library.

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A biomechanical approach

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PREFACE

In the literature pertaining to back pain, the musculoskeletal components of the thorax have received little attention. The reference list at the end of this text reflects the paucity of research available for review. And yet, clinicians are presented daily with the challenge of treating both acute and chronic thoracic pain. It was this challenge which initiated the clinical work presented in this text.

A biomechanical approach to treatment of the thorax requires an understanding of its normal behaviour. Without a working model, the clinician is limited to using unreliable symptoms for direction and treatment planning. If we understand how the musculoskeletal system behaves normally, we can then apply this knowledge to the examination of the painful thorax. A systematic examination of mobility/stability of the associated bones and joints can then be done. Since function is related to structure, an understanding of the anatomy is required.

The clinical investigation began in 1990 when Jan Lowcock presented a paper on stability testing of the thorax to the Canadian Orthopaedic Manipulative Physiotherapists. I am indebted to her, and many others, for the subsequent academic and clinical discussions which lead to the evolution of the biomechanical model presented here. Much of this material remains empirical and requires validation through research.

The first chapter reviews the anatomy of the thorax as it pertains to the biomechanical model. The emphasis has been placed on osseous and articular anatomy although the muscular and neural contribution to function is acknowledged. Chapter two describes the biomechanical model and chapters three to five the clinical application of this model to examination and treatment of the thorax. The purpose of this text is to provide the clinician with the ability to assess and treat articular dysfunction of the thorax. The reader is referred to other texts for a review of postural analysis, myofascial syndromes and neural dysfunction.

I would like to extend my gratitude and recognition to Mr. Frank Crymble who was responsible for the cover design and all of the art work and photographs in this text. To my colleagues at DOPC for their ongoing support and constructive reviews of 'yet another presentation on the thorax', my special thanks. And finally, to Thomas, Michael and Chelsea, thank you.

British Columbia, 1994 D.L.

CONTENTS

1
ANATOMY

The thorax can be divided into four regions according to anatomical and biomechanical differences. The vertebromanubrial region (upper thorax) includes the first two thoracic vertebrae, ribs one and two and the manubrium. The vertebrosternal region (middle thorax) includes T3 to T7, the third to seventh ribs and the sternum. T8, T9 and T10 together with the eighth, ninth and tenth ribs form the vertebrochondral region (middle/lower thorax). The lowest region is the thoracolumbar junction which includes the T11 and T12 vertebrae and the eleventh and twelfth ribs. The regional anatomy pertinent to the biomechanical model will be described in this chapter.

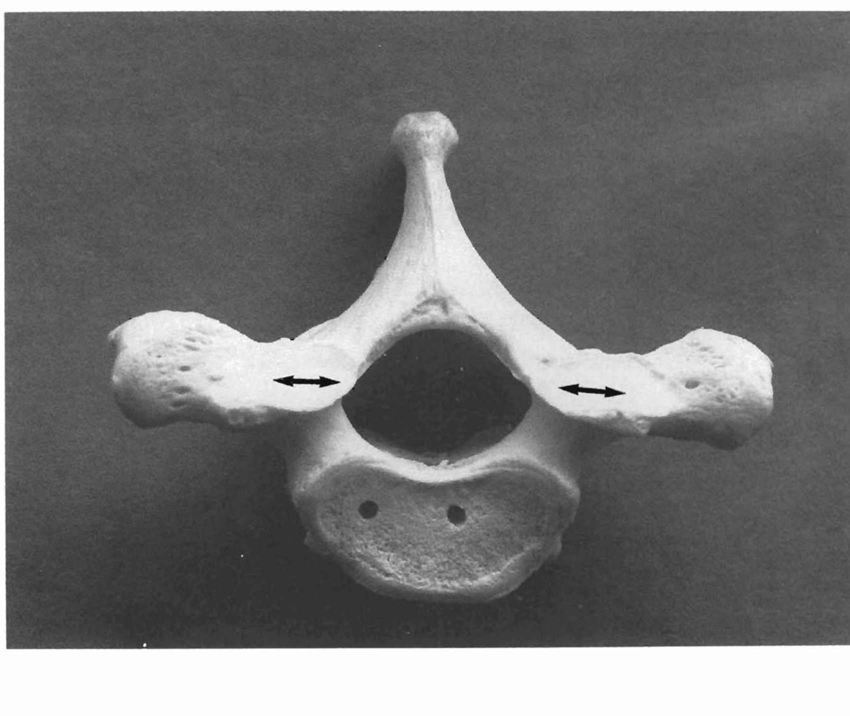


Figure 1.
The superior aspect of the first thoracic vertebra. The zygapophyseal joints lie in the coronal plane.

VERTEBROMANUBRIAL REGION

The first thoracic vertebra is atypical. It has a large, nonbifid spinous process, clublike at its end. The superior aspect of the spinous process tends to lie in the same transverse plane as the T1-2 zygapophyseal joints. The facets on the superior articular processes lie in the coronal body plane (Fig. 1) while those on the inferior articular process (Fig. 2) present a gentle curve in both the transverse and sagittal planes. The zygapophyseal joints are synovial.

The transverse processes are long and thick. They are located between the superior and inferior articular processes (Fig. 3) at the dorsal aspect of the pedicle and are ideally situated for palpation of intervertebral motion. On the ventral aspect of the transverse process there is a deep, concave facet which articulates with a convex facet on the first rib to form the costotransverse joint. In the normal upright posture, the orientation of this joint is anteroinferior

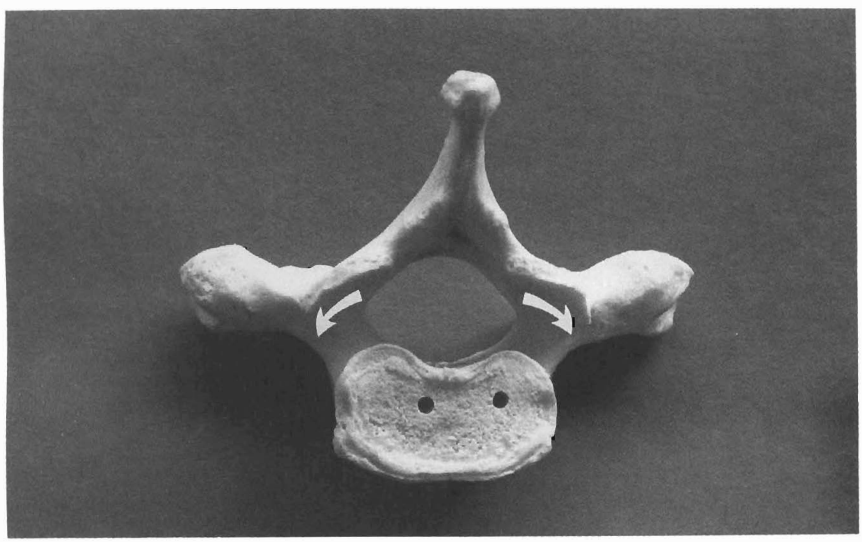


Figure 2.
The inferior aspect of the first thoracic vertebra. The zygapophyseal joints are gently convex in both the transverse and sagittal planes. The ventral aspect of the transverse process contains a concave facet for articulation with the first rib.

Figure 3.
Anterolateral view of the first thoracic vertebra. The uncinate process at each posterolateral corner creates a concavity on the superior aspect of the vertebral body. There is a full facet at the superolateral aspect of the vertebral body for the head of the first rib. A demi-facet on the inferolateral aspect articulates with the head of the second rib in the second decade of life. Note the concave facet on the transverse process for articulation with the first rib.

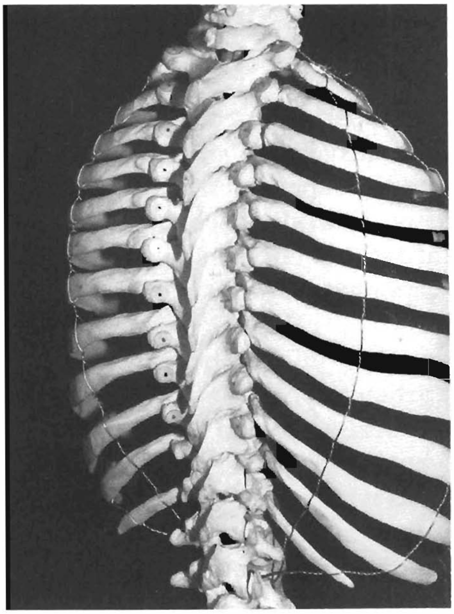


Figure 4.
Posterolateral view of the articulated thorax. Note the change in the orientation of the costotransverse joint from the vertebromanubrial region to the vertebrochondral region.

(Fig. 4). Like the zygapophyseal joint, the costotransverse joint is synovial.

The superior aspect of the vertebral body of T1 is concave in the coronal plane. This concavity is formed by the uncinate process at each posterolateral corner. These processes articulate with the inferior aspect of the body of C7 to form the non-synovial, uncovertebral joint[1]. There are two ovoid facets on either side of the vertebral body for articulation with the head of the first rib. The inferior aspect of the vertebral body of T1 is flat and contains a small facet at each posterolateral corner for articulation with the head of the second rib. This articulation is incomplete until early adolescence when a secondary ossification centre appears to complete the formation of the head of the rib[2,3]. In children, the head of the second rib only articulates with T2.

The first rib (Fig. 5) is the shortest of the twelve and the broadest at its anterior end. The first sternochondral joint is unique in that it is fibrous rather than synovial. The first costocartilage is the shortest and this, together with the fibrous sternochondral joint, contributes to the stability of the first ring. The convex head of the first rib articulates with the body of T1 at the costovertebral joint. The neck of the rib is located between the head and the tubercle. The articular portion of the tubercle is convex and directed posterosuperiorly when the head and neck are in the normal upright posture. The second rib is about twice as long as the first and its features are similar to the vertebrosternal region described below. Anteriorly, the cartilage of the second ring articulates with both the manubrium and the sternum at the manubriosternal symphysis.

The manubrium (Fig. 6) is a broad triangular shaped bone which articulates with the clavicle and the costocartilage of the first and second ribs. The manubriosternal symphysis usually remains separate throughout life although ossification can occur (Fig. 7).

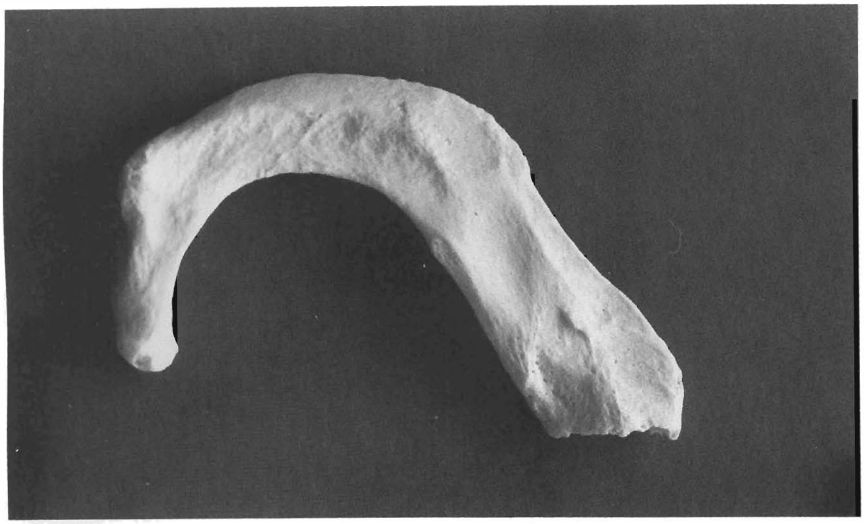


Figure 5.
Superior aspect of the first rib.

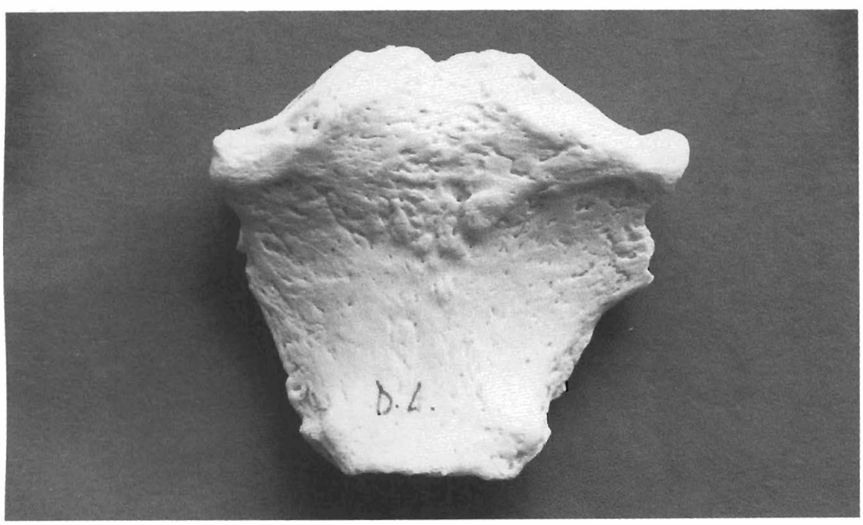


Figure 6.
The manubrium.

VERTEBROSTERNAL REGION

The vertebrae in this region (T3 to T7) have long, thin, overlapping spinous processes (Fig. 8). The tip of the spinous process can be three finger widths inferior to the transverse process of the same vertebra and frequently deviates from the midline. Consequently, it is an unreliable point for palpating intervertebral motion.

The facets on both the superior and inferior articular processes present a gentle curve in both the transverse and sagittal planes[4] (Fig. 9). This orientation permits multidirectional movement. If two mixing bowls are placed one inside the other, a model of the zygapophyseal joints can be made (Fig. 10). The top bowl can rotate forward, backward, sideways and around the bottom bowl. Translation of the top bowl meets immediate resistance. The coro-

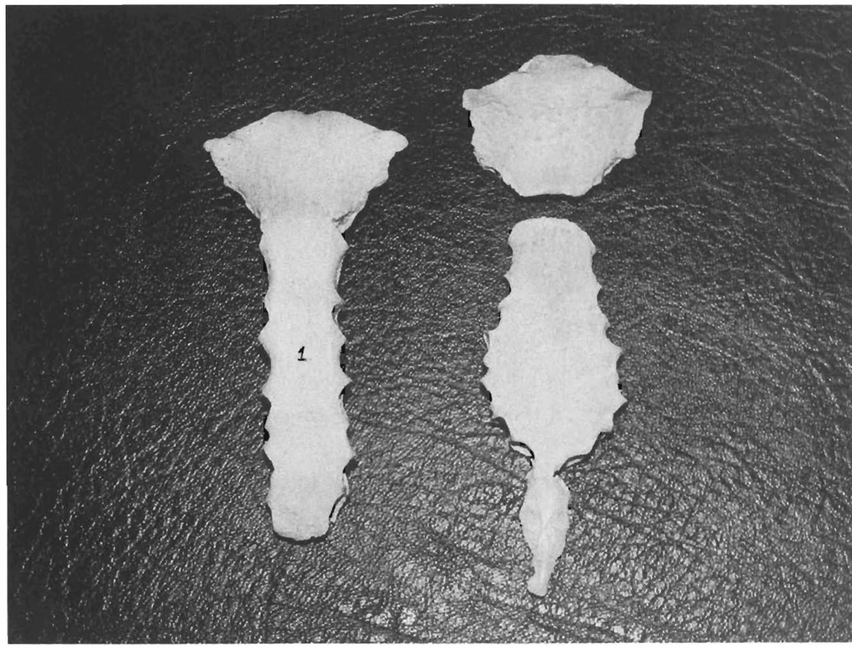


Figure 7.
The manubriosternal symphysis is usually maintained through life, however ossification can occur.

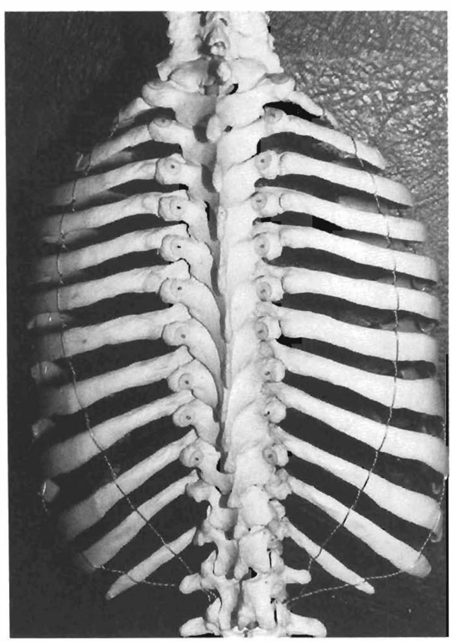


Figure 8.
Posterior view of the articulated thorax.

nal orientation of the superior articular processes resists posteroanterior translation of the superior vertebra.

The transverse processes, located at the dorsal aspect of the pedicle between the superior and inferior articular processes, are ideally situated for palpation of intervertebral joint motion. The ventral aspect of the transverse process (Fig. 11) contains a deep, concave facet for articulation with the rib of the same number. This curva-

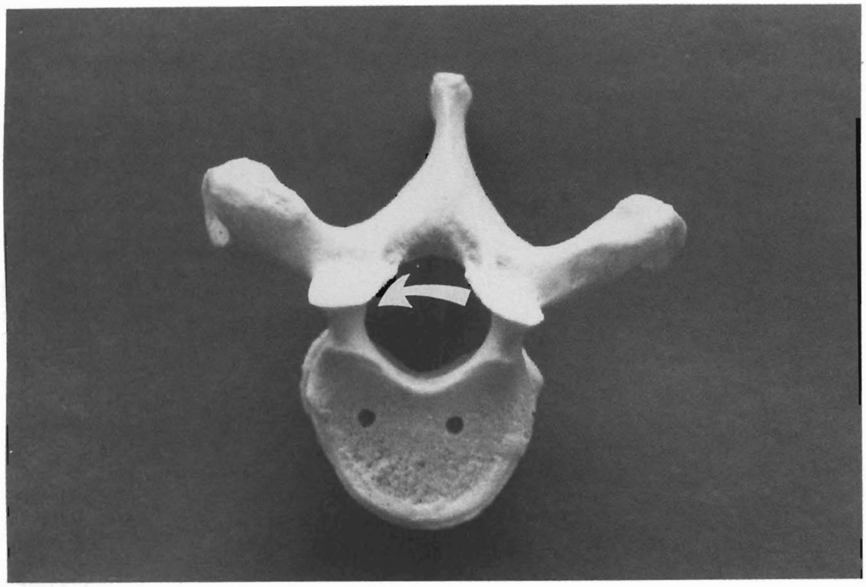


Figure 9.
The superior aspect of the fourth thoracic vertebra. The zygapophyseal joint is gently convex in both the transverse and sagittal planes. The ventral aspect of the transverse process contains a concave facet for articulation with the fourth rib.

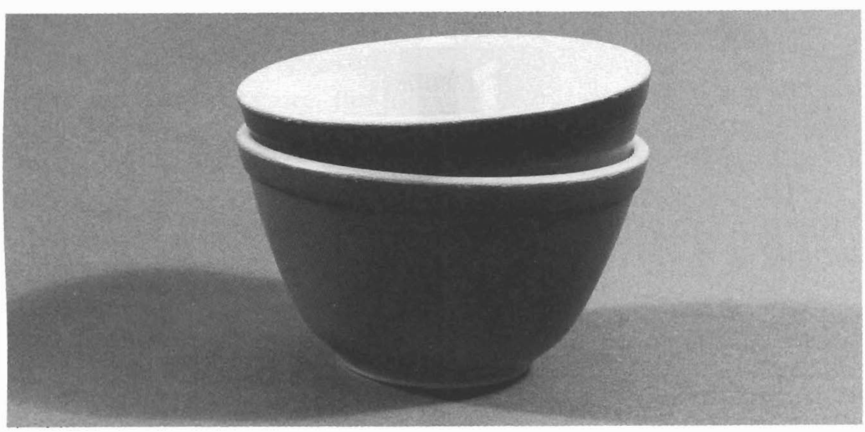


Figure 10.
Two mixing bowls model the potential biomechanics of the zygapophyseal joints in the thorax.

Figure 11.
Anterolateral view of the fourth thoracic vertebra. Note the concave facet on the transverse process for articulation with the fourth rib as well as the two demi-facets on the lateral aspect of the vertebral body for articulation with the heads of the fourth and fifth ribs.

ture (Fig. 12) influences the conjunct rotation which occurs when the rib glides in a superoinferior direction. When the tubercle of the rib glides superiorly, the curvature forces the rib to rotate anteriorly. Conversely, posterior rotation of the rib occurs when the

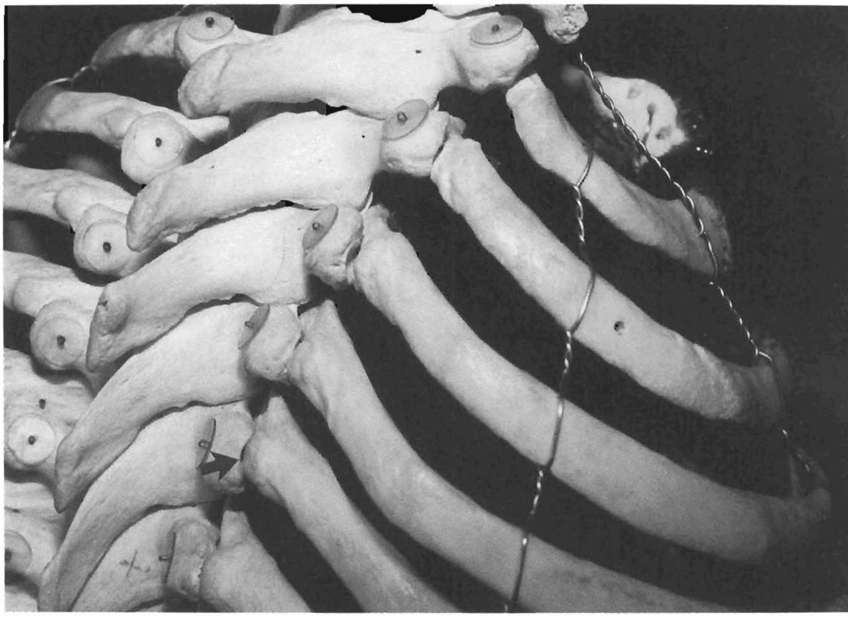


Figure 12.
Posterolateral view of the articulated thorax, vertebrosternal region. Note the curvature of the fifth costotransverse joint (arrow).

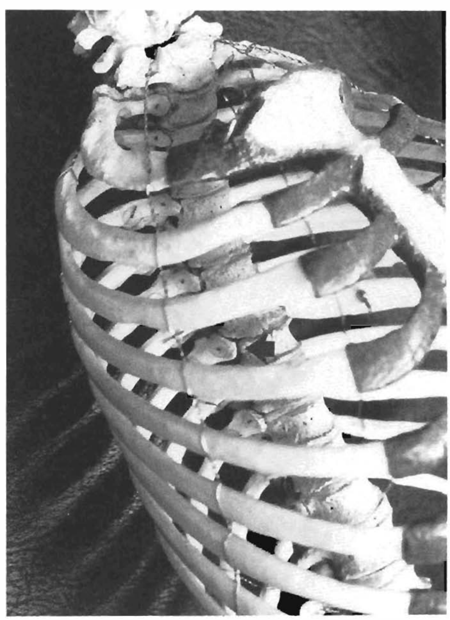
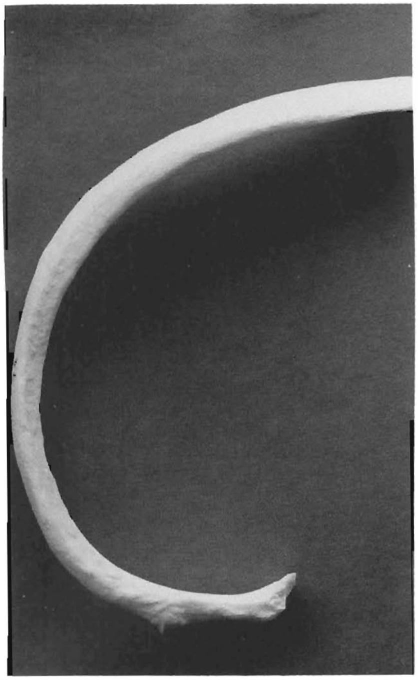


Figure 13.
Anterolateral view of the articulated thorax. Note the costovertebral joint, vertebrosternal region (arrow).

tubercle glides inferiorly relative to the transverse process. In the normal upright posture, the orientation of the facet on the transverse process is anterolateral.

The posterolateral corners of both the superior and inferior aspects of the vertebral body contain an ovoid demifacet for articulation with the head of the rib (Fig. 11). Development of the superior costovertebral joint is delayed until early adolescence[2,3] accounting for the flexibility of the young thorax.



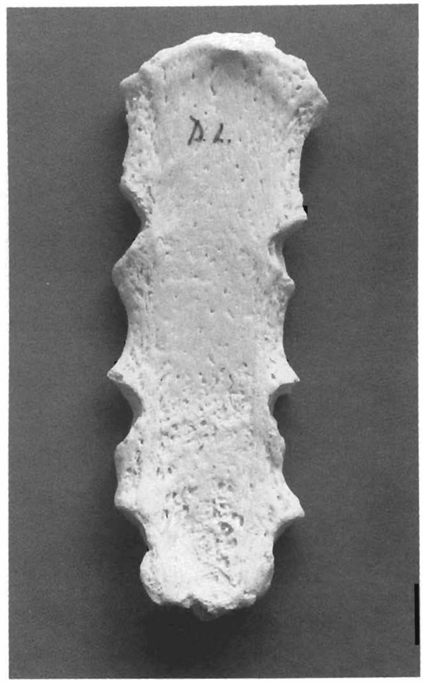


Figure 14.
The fourth rib.

Figure 15.
The sternum.

In the skeletally mature, the joint between the head of the rib and the adjacent vertebral bodies is divided into two synovial cavities, separated by the intra-articular ligament (Fig. 13). The capsule is supported by the radiate ligament which sends fibres from the head of the rib both anteriorly and posteriorly to blend with the vertebral body of the level above, the intervertebral disc and the vertebral body of the level below. The costovertebral joint is a compound, synovial joint.

The neck of the rib lies parallel to the transverse process, joined by the costotransverse or interosseous ligament. The non-articular portion of the tubercle receives the lateral attachment of the short, lateral costotransverse ligament. This ligament lies in the transverse plane between the transverse process and the rib. The superior costotransverse ligament has a variable number of bands which run in a superoinferior direction from the inferior aspect of the transverse process to the neck of the rib below. The neurovascular elements of the thoracic segment emerge between the bands of this ligament. The shaft of the rib is long and thin and twists to a variable degree at the posterior angle (Fig. 14).

Very little is known about the anatomy and age related changes of the intervertebral disc in the thorax. They are thinner than the cervical and lumbar intervertebral discs even in youth. They are supported anteriorly and posteriorly by wide longitudinal ligaments.

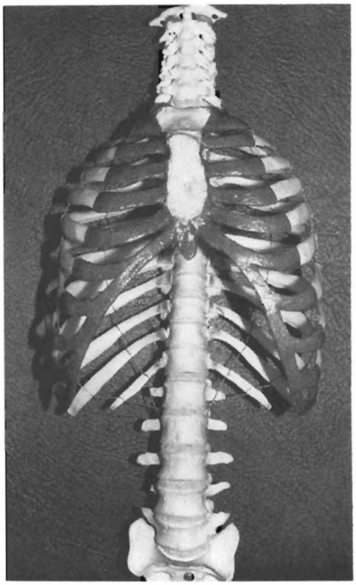


Figure 16.
Anterior view of the articulated thorax.

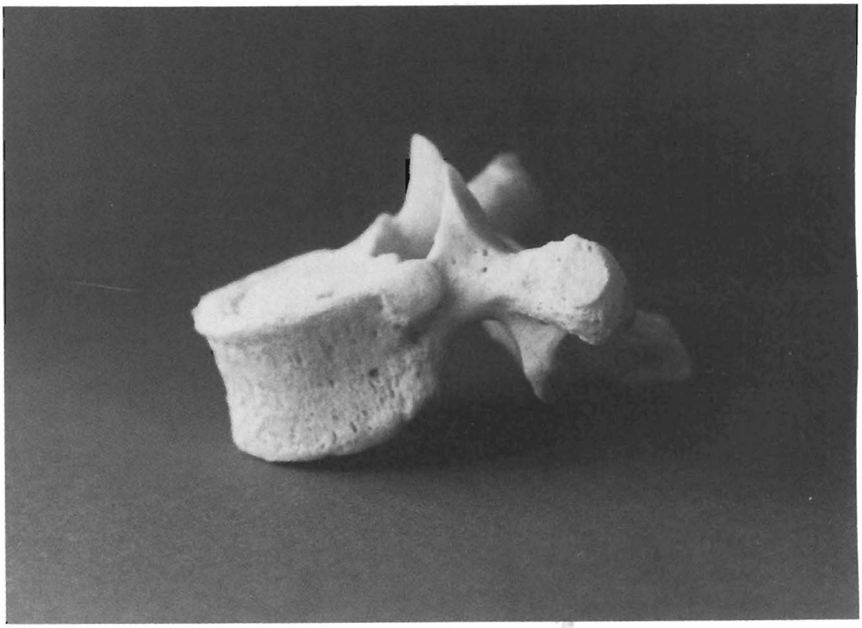


Figure 17.
Anterolateral view of the eighth thoracic vertebra. Note the planar facet on the transverse process for articulation with the eighth rib as well as the large superior demi-facet for articulation with the head of the eighth rib and the small demi-facet for articulation with the head of the ninth rib.

The sternum (Figs. 7, 15) has eight full concave facets which articulate with the costocartilages of ribs three to six. Superiorly, the second rib articulates with the sternum at a demi-facet; inferiorly, the seventh rib articulates with both the xiphoid and the sternum. These joints are synovial unlike the lateral costochondral joints which are fibrous, the periosteum and perichondrium continuous. The costocartilage increases in length from the first to the seventh ribs and then decreases to the tenth (Fig. 16). Thus the lower part of the vertebrosternal region (ribs 6, 7) has greater flexibility anteriorly than the upper part (ribs 3, 4).

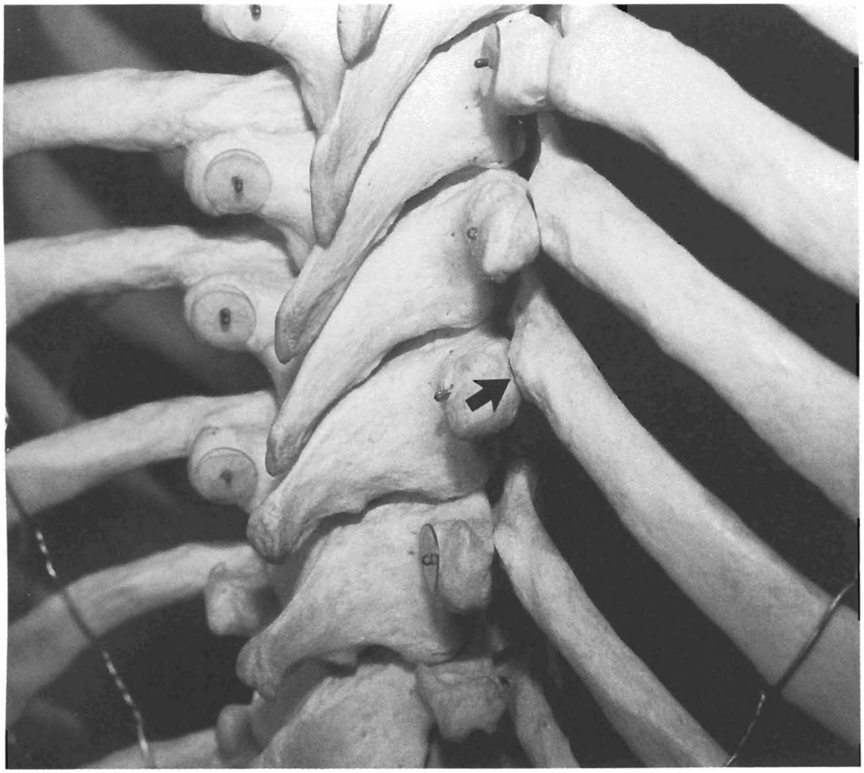


Figure 18.
Posterolateral view of the articulated thorax, vertebrochondral region. Note the planar nature of the ninth costotransverse joint (arrow).

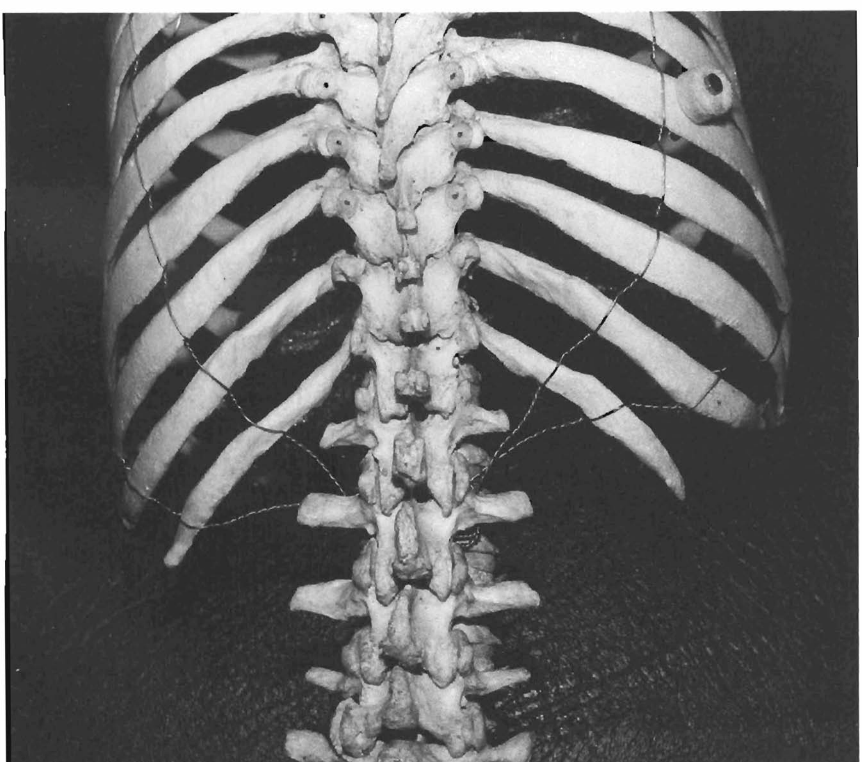


Figure 19.
Posterior view of the articulated thorax, thoracolumbar region. Occasionally the spinous processes are bifid.

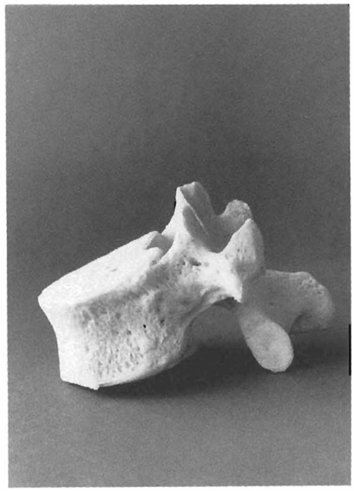


Figure 20.
Lateral view of the twelfth thoracic vertebra. Note the change in direction of the facets on the superior and inferior articular processes. There is one facet on the lateral aspect of the vertebral body for articulation with the head of the twelfth rib. There is no facet on the small transverse process, there is no costotransverse joint.

Figure 21.
The eleventh and twelfth thoracic and the first lumbar vertebrae. Note the orientation of the zygapophyseal joints.

VERTEBROCHONDRAL REGION

The vertebrae in this region (T8, 9, 10) differ from the vertebrosternal region in the following aspects. The spinous process is shorter (Figs. 8, 17), although still directed inferiorly such that the tip lies close to the transverse plane of the transverse process of the inferior vertebra.

The facet on the ventral aspect of the transverse process is flat and faces anterolateral and superior (Fig. 18). Therefore, when the tubercle of the rib glides superiorly, it also glides posteromedially with minimal conjunct rotation. When the tubercle of the rib glides inferiorly, it also glides anterolaterally following the plane of the costotransverse joint.

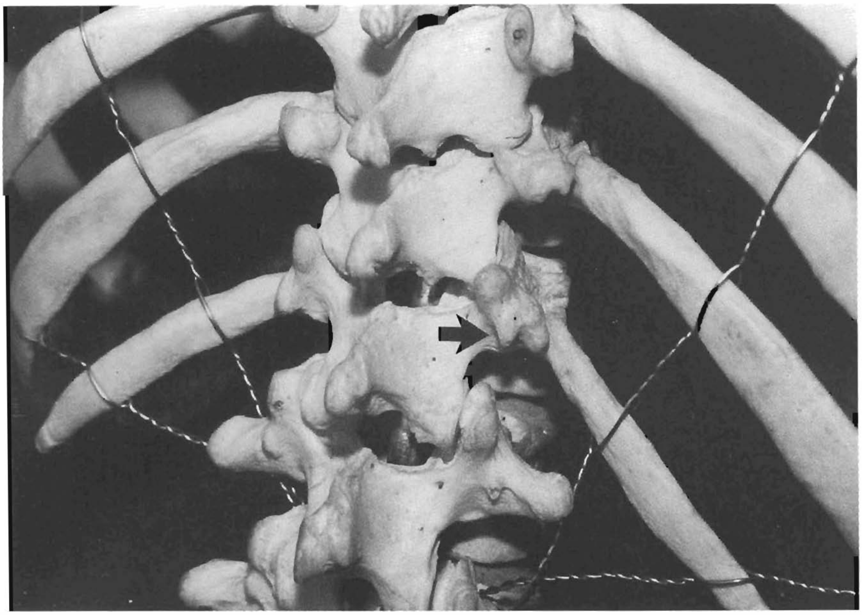


Figure 22.
The transverse processes of the twelfth thoracic vertebrae are small tubercles (arrow) and cannot be used for palpating intervertebral motion.

T8 and T9 have four demifacets for articulation with the head of the eighth and ninth ribs. T10 is variable. Often, there is only a small articulation between the superior aspect of the head of the tenth rib and the inferior aspect of the vertebral body of T9. Occasionally, the tenth rib will articulate only with T10 at the base of the pedicle via an unmodified ovoid joint.

Anteriorly the eighth, ninth and tenth ribs articulate indirectly with the sternum via a series of cartilaginous bars which blend with the seventh costocartilage (Fig. 16). There is a variable number of synovial joints between the costocartilages (interchondral joints). This arrangement permits greater flexibility.

THORACOLUMBAR JUNCTION

The spinous processes of T11 and T12 are short, stout and contained entirely within the lamina of their own vertebra (Figs. 8, 19, 20). The facets on the articular processes of T11 (Fig. 21) resemble those of both the vertebrosternal and vertebrochondral regions. The facets on the inferior articular process of T12 resemble the lumbar region. They have a coronal and sagittal component and when articulated with L1 restrict axial rotation. The orientation of T11-12 does not restrict axial rotation.

Laterally, the transverse processes are small tubercles (Fig. 22), the mamillary processes are larger and more superficial. The spinous process is a more reliable point for palpating intervertebral motion in this region.

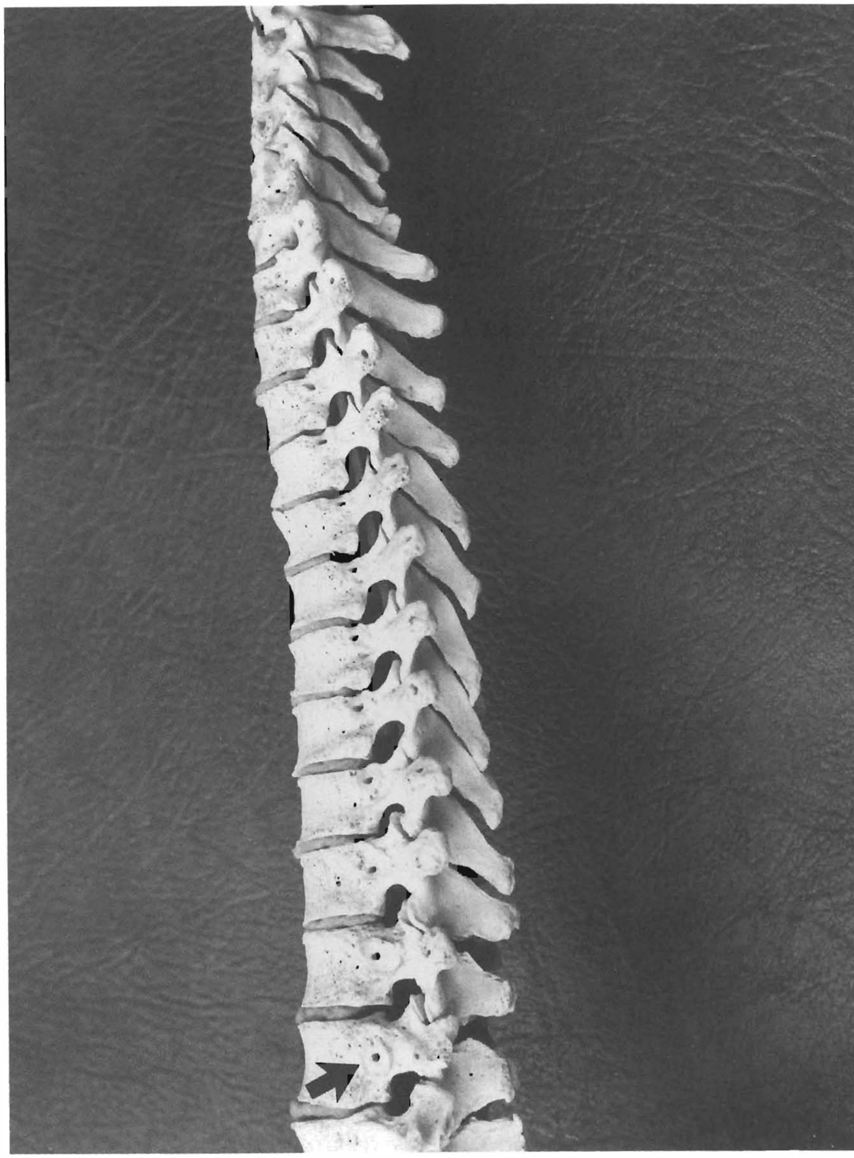


Figure 23.
Lateral view of the thoracic spine. Note the unmodified ovoid facet (arrow) for the head of the twelfth rib.

The heads of the eleventh and twelfth ribs articulate only with the vertebral body at the base of the pedicle via an unmodified ovoid joint (Fig. 23). There is no costotransverse joint in this region. The ribs do not have a neck and do not twist significantly. They remain detached from the rest of the thorax anteriorly (Fig. 16) and provide attachment for the diaphragm and trunk musculature. The shape of the costovertebral joint facilitates multi-directional movement of the vertebral body even when the large muscles contract and fix the eleventh and twelfth ribs. The eleventh segment (T11, T12, eleventh rib) is the most flexible in the thorax.

2
BIOMECHANICS

The following material has been previously published, in part, in the Journal of Manual and Manipulative Therapy[5] and in Physical Therapy of the Cervical and Thoracic Spine[6] and is reproduced here with permission from the author and the publishers.

A biomechanical approach to the assessment and treatment of musculoskeletal dysfunction of the thorax requires an understanding of its normal behaviour. Without a working model, the clinician is limited to using often unreliable symptoms for direction and treatment planning. If we understand how the osteoarticular system behaves normally, we can then apply this knowledge when examining the deviant movement patterns of the thorax. A systematic examination of mobility/stability of the associated bones and joints can then be done. The intent of this chapter is to present a model of in vivo biomechanics of the thorax which has been used clinically as the basis for assessing and treating mechanical dysfunctions of both the spinal and costal joints. Some parts of this model have been substantiated through scientific research[7] while others remain empirical.

LITERATURE REVIEW

Reference to the literature reveals very little that is known about the in vivo biomechanics of the thoracic region. Four studies of the human thorax[8,9,10,11] were based on three dimensional mathematical models and are difficult to apply clinically. Andriacchi[10] noted that the rib cage increased the bending stiffness of the spine by a factor of two in extension. He found that when the rib cage was left intact, the spine could support three times the load in compression before lateral instability occurred. The clinical implication of this is that any loss of integrity of the segmental 'thoracic ring' would impair the ability of the entire cage to sustain a vertical load.

Saumarez[8] noted that there can be considerable independent movement of the sternum and the spine, "thus allowing mobility of the spine without forcing concomitant movements of (the) rib cage". Neither study[8,10] proposed a kinematic model of the in vivo biomechanics of the thorax.

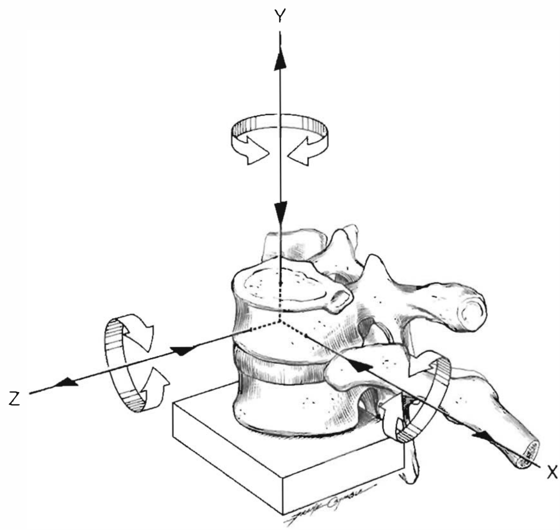


Figure 24.
In an in vitro study by Panjabi, Brand and White[7], 396 load displacement curves were obtained for six degrees of motion at each thoracic segment. The amplitude of the induced motion as well as the amplitude and direction of any consequential coupled motion was recorded. From Lee[5,6] with permission.

Panjabi, Brand and White[7] investigated the mechanical properties of the thoracic spine through an in vitro study. Three hundred and ninety six load displacement curves were obtained for six degrees of motion, comprising three translations and three rotations along and about the X, Y and Z axes for each of the eleven motion segments of the thoracic spine (Fig. 24). The specimens tested ranged in age from 19 to 59 years. The motion segment included the anterior interbody joint, the posterior zygapophyseal joints, the costovertebral and costotransverse joints. The ribs were cut 3 cm lateral to the costotransverse joints and the front of the chest was removed. The functional spinal unit was left intact, however, *the functional costal unit was not*. The results of this study will be discussed later.

DEFINITION OF TERMINOLOGY

To facilitate the subsequent discussion, the terminology used requires definition. Osteokinematics[12] refers to the study of motion of bones regardless of the motion of the joints. Angular motions are osteokinematic motions and are named according to the axis about which the bone rotates. Flexion/extension occurs about a coronal axis, anterior/posterior rotation about a paracoronal axis, sideflexion (lateral bending) about a sagittal axis and axial rotation about a vertical axis. Coupled motion refers to the combination of movements which occur as a consequence of an induced motion.

Linear motions are named according to the axis along which the bone translates. Mediolateral translation occurs along a coronal axis, anteromedial/posterolateral translation along a paracoronal

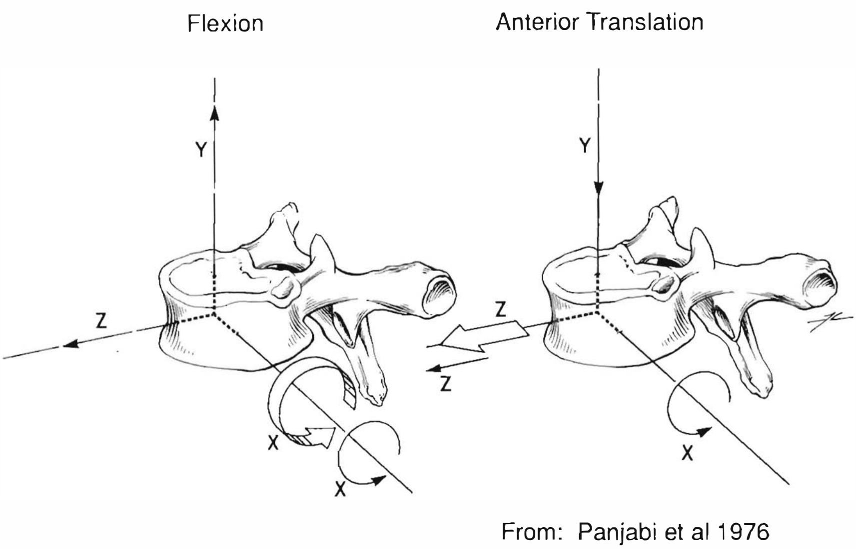


Figure 25.
Forward sagittal rotation around the X axis induced anterior translation along the Z axis and slight distraction along the Y axis. Anterior translation along the Z axis induced forward sagittal rotation around the X axis and slight compression along the Y axis. Redrawn from Panjabi, Brand and White[7]. From Lee[5,6] with permission.

axis, traction/compression along a vertical axis, and anteroposterior translation along a sagittal axis.

Arthrokinematics[12] refers to the study of motion of joints regardless of the motion of the bones. These movements are named according to the direction the joint surfaces glide.

HABITUAL MOVEMENTS

The thorax is capable of six degrees of motion along and about the three cardinal axes of the body; however, no movement occurs in isolation[7]. In other words, all angular motion is coupled with a linear motion and vice versa. The habitual movements of the thorax include forward and backward bending, lateral bending and axial rotation of the head and trunk. Elevation of the arm also requires movement of the upper thorax. Simultaneously, the chest moves during inspiration and expiration. The biomechanics of the thorax varies according to the region considered. The common features and the regional differences will be described.

Forward bending

Flexion of the thoracic vertebrae occurs during forward bending of the head and trunk. Panjabi, Brand and White[7] found that forward sagittal rotation (flexion) around the X axis was coupled with anterior translation along the Z axis (.5 mm) and very slight distraction (Fig. 25). When anterior translation along the Z axis (1 mm) was induced in the experimental model, forward sagittal rotation around the X axis was coupled with slight compression.

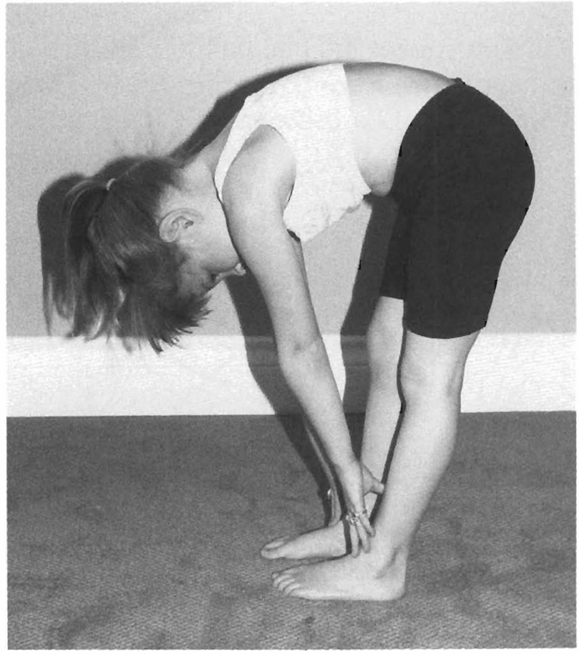


Figure 26.
Flexion of the thoracolumbar spine in a 6 year old.

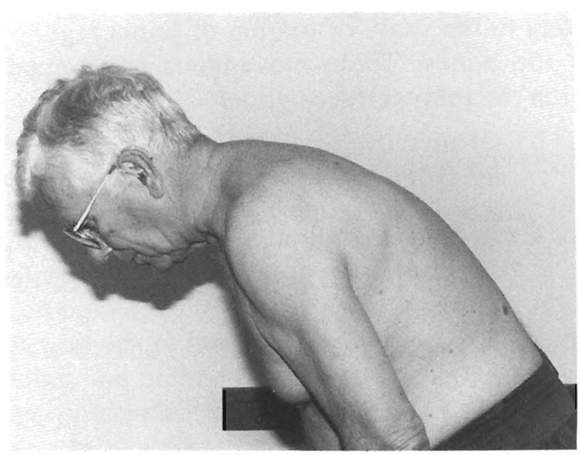


Figure 27.
Flexion of the thoracolumbar spine in a 71 year old.

The osteokinematic motion of the ribs during forward sagittal rotation of the thoracic vertebrae was not noted in the study by Panjabi et al[7]. Clinically, three movement patterns can occur and are dependant upon the relative flexibility between the vertebral column and the rib cage. In the very young (less than 12 years of age), the head of the rib does not articulate with the inferior aspect of the superior vertebra. The secondary ossification centre for the superior aspect of the head of the rib does not develop until puberty, therefore the young chest is very mobile (Fig. 26). In the skeletally mature, the superior costovertebral joints limit the quantity of vertebral rotation in all three planes. With increasing age, the costocartilages stiffen and decrease the flexibility of the rib cage (Fig. 27). This change in relative flexibility between the vertebral column and the rib cage is apparent when examining the specific costal osteokinematics during forward and backward bending of the trunk.

Mobile thorax

During forward bending of the mobile thorax, forward sagittal rotation of the superior vertebra couples with anterior translation. This anterior translation 'pulls' the superior aspect of the head of the rib forward at the costovertebral joint inducing an anterior rota-

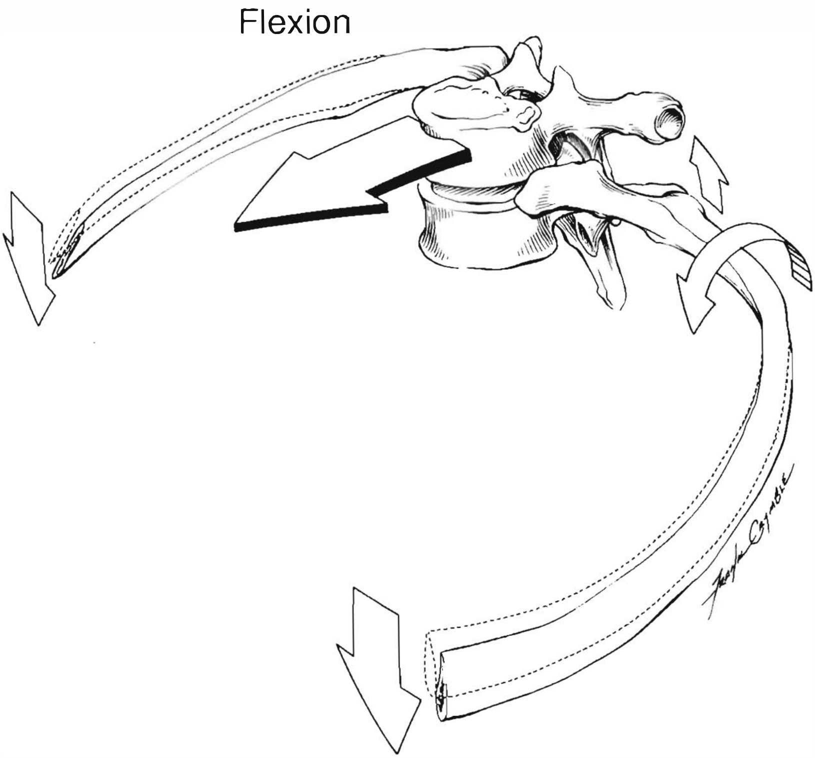


Figure 28.
The osteokinematic and arthrokinematic motion proposed to occur in the mobile thorax during forward bending - vertebrosternal region. From Lee[5,6] with permission.

tion of the rib. The rib rotates about a paracoronal axis along the line of the neck of the rib such that the anterior aspect travels inferiorly while the posterior aspect travels superiorly (Fig. 28). At those levels where the superior costovertebral joint does not exist (1, 11, 12) or is very small (10), the anterior translation of the superior vertebra cannot facilitate anterior rotation of the rib below.

Arthrokinematically, the inferior facets of the superior thoracic vertebrae glide superoanteriorly at the zygapophyseal joints during flexion. The superior articular processes of the inferior thoracic vertebrae present a gentle curve convex posterior in both the sagittal and transverse plane. The superior motion of the inferior articular processes follows the curve of this convexity and the result is a superoanterior glide. Thus, the arthrokinematic motion of the joint surfaces supports the osteokinematic motion of the vertebrae, anterior translation being coupled with forward sagittal rotation.

In the vertebrosternal region of the thorax, the anterior rotation of the neck of the rib results in a *superior glide* of the tubercle at the costotransverse joint. Since the costotransverse joints of T3 to T7 are concavoconvex (the facet on the transverse process is concave) in both the sagittal and transverse plane, the superior glide of the

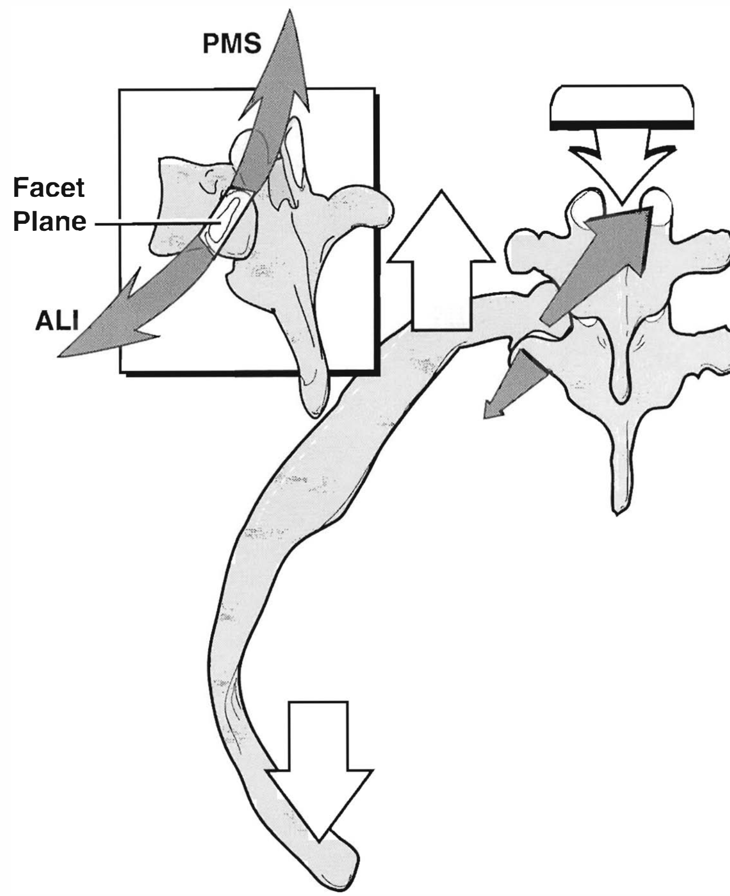


Figure 29.

The osteokinematic and arthrokinematic motion proposed to occur in the mobile thorax during forward bending - vertebrochondral region.

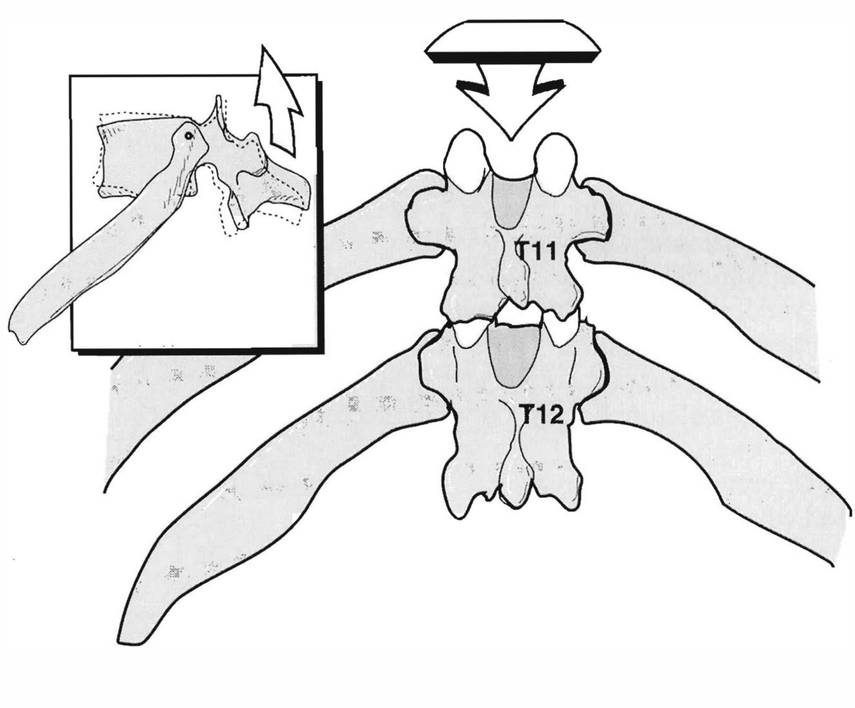


Figure 30.

The osteokinematic and arthrokinematic motion proposed to occur in the mobile thorax during forward bending - thoracolumbar region.

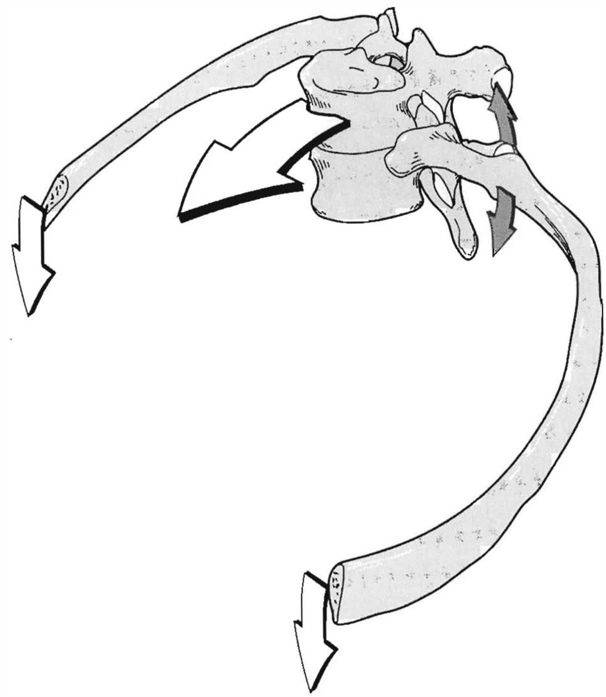


Figure 31.
The osteokinematic and arthrokinematic motion proposed to occur in the stiffer thorax during forward bending - vertebrosternal region.

tubercle results in anterior rotation of the neck of the rib. Once again, the arthrokinematic motion at the costotransverse joint supports the osteokinematic motion of the rib during forward bending of the trunk.

In the vertebrochondral region of the thorax (T8 - T10) the costotransverse joints are planar and oriented in an anterolateral and superior direction (Fig. 18). The posteromediosuperior (PMS) glide of the tubercle (Fig. 29) does not induce an anterior rotation of the neck of the rib to the same degree as the middle and upper ribs.

The first rib is always less mobile than T1 and the movement pattern in the vertebromanubrial region is described below (stiffer thorax). In the thoracolumbar region (Fig. 30), the eleventh and twelfth costovertebral joints are unmodified ovoid in shape and flexion of the thoracic vertebra can be a pure spin.

Stiffer thorax

The ribs are less mobile than the vertebral column when the stiffer thorax is flexed. During forward bending of the head and trunk, the anterior aspect of the rib travels inferiorly while the posterior aspect travels superiorly. Once the mobility of the rib cage is

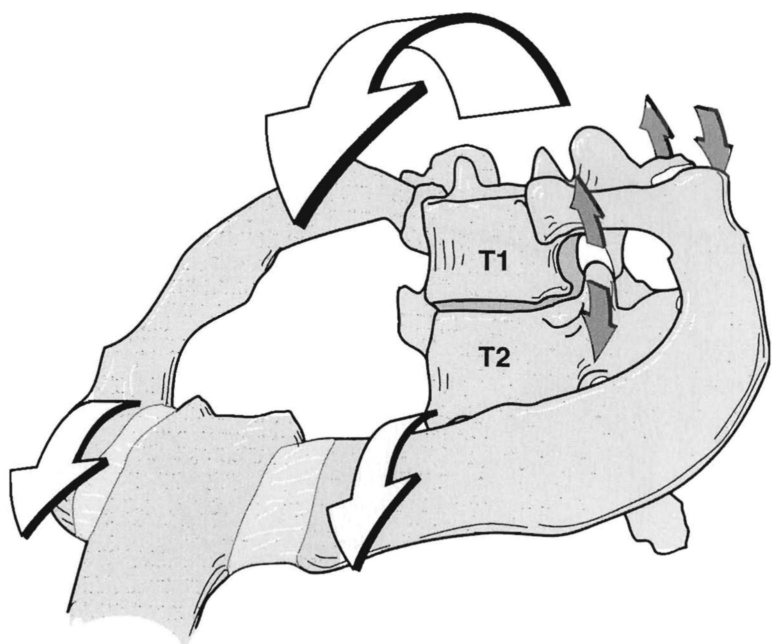


Figure 32.
The osteokinematic and arthrokinematic motion proposed to occur in the vertebromanubrial region during forward bending.

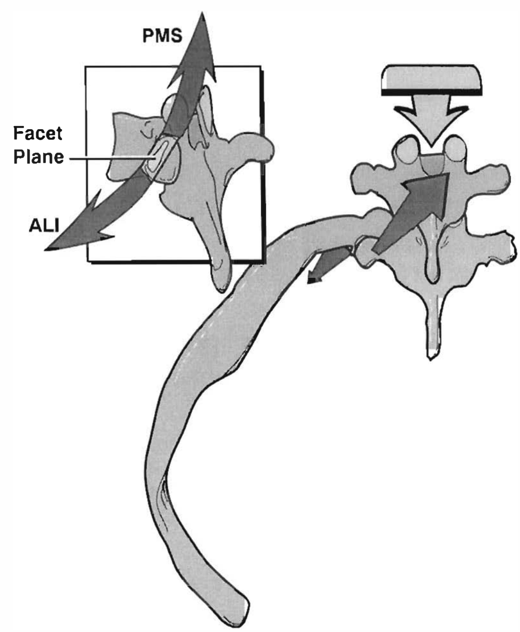


Figure 33.
The osteokinematic and arthrokinematic motion proposed to occur in the stiffer thorax during forward bending - vertebrochondral region.

exhausted, the thoracic vertebrae continue to flex on the stationary ribs (Figs. 31, 32). The arthrokinematics of the zygapophyseal joints remain the same as in the mobile thorax, however the degree of anterior translation is less. At the costotransverse joints, the arthrokinematics are different. As the thoracic vertebrae continue to flex, the concave facets on the transverse processes of T1 to T7 glide superiorly relative to the tubercle of the ribs. The result is a relative *inferior glide* of the tubercle of the rib at the costotransverse joint.

In the vertebrochondral region (Fig. 33), the facets of the costotransverse joints are planar and the relative glide of the rib is anterolateroinferior.

Rigid thorax

When the relative flexibility between the vertebral column and the rib cage is the same, there is no palpable movement between the thoracic vertebrae and the ribs. Some superior gliding occurs at the zygapophyseal joints, but very little if any posteroanterior translation occurs.

Limiting factors

All of the ligaments posterior to and including the posterior half of the intervertebral disc limit flexion of the thoracic spinal unit. In a study by Panjabi, Hausfeld and White[13], the thoracic spinal unit was loaded to failure in both flexion and extension. Failure was defined as complete separation of the two vertebrae or more than 10 mm of translation or 45 degrees of rotation. The ligaments were transected sequentially and the contribution of the various ligaments to stability was noted. In flexion, they found that the unit remained stable until the costovertebral joint was transected. The integrity of the posterior one-third of the disc and the costovertebral joints is critical to anterior translation stability in the thorax.

Backward bending

Extension of the thoracic vertebrae occurs during backward bending of the trunk and during bilateral elevation of the arms. Flexion of the upper thorax occurs when the head is bent backward. Panjabi, Brand and White[7] found that backward sagittal rotation (extension) around the X axis was coupled with posterior translation along the Z axis (1 mm) and very slight distraction (Fig. 34). When backward translation along the Z axis (2.5 mm) was induced in the experimental model, posterior sagittal rotation around the X axis and very slight compression also occurred.

The osteokinematic motion of the ribs that occurs during backward sagittal rotation of the thoracic vertebrae was not noted in the study by Panjabi et al[7]. Clinically, the movement patterns observed depend on relative flexibility between the vertebral column and the rib cage. Three patterns have been noted.

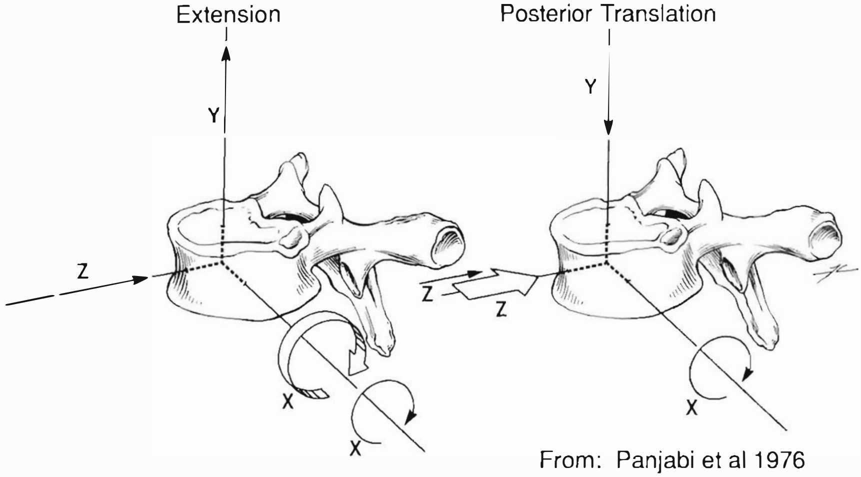


Figure 34.
Backward sagittal rotation around the X axis induced posterior translation along the Z axis and slight distraction along the Y axis. Posterior translation along the Z axis induced backward sagittal rotation around the X axis and slight compression along the Y axis. Redrawn from Panjabi, Brand and White[7]. From Lee[5,6] with permission.

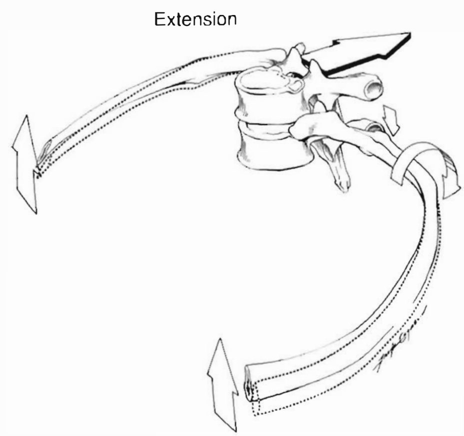


Figure 35.
The osteokinematic and arthrokinematic motion proposed to occur in the mobile thorax during backward bending - vertebrosternal region. From Lee[5,6] with permission.

Mobile thorax

During extension of the mobile thorax, backward sagittal rotation of the superior vertebra couples with posterior translation and 'pushes' the superior aspect of the head of the rib backward at the costovertebral joint inducing a posterior rotation of the rib (Fig. 35). The rib rotates about a paracoronal axis along the line of the neck of the rib such that the anterior aspect travels superiorly while the posterior aspect travels inferiorly. At those levels where the superior costovertebral joint does not exist (1, 11, 12) or is very small (10), the posterior translation of the superior vertebra does not force the rib to posteriorly rotate relative to its transverse process.

Arthrokinematically, the inferior facets of the superior thoracic vertebrae glide inferoposteriorly at the zygapophyseal joints during extension. The superior articular processes present a gentle curve that is convex posteriorly in both the sagittal and transverse

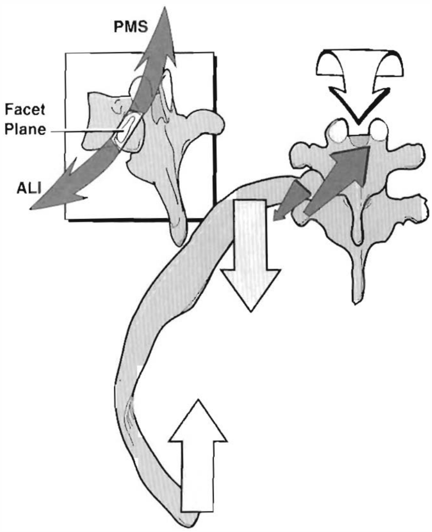


Figure 36.
The osteokinematic and arthrokinematic motion proposed to occur in the mobile thorax during backward bending - vertebrochondral region.

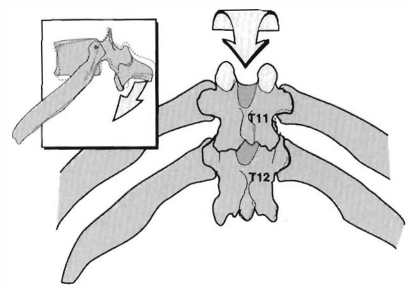


Figure 37.
The osteokinematic and arthrokinematic motion proposed to occur in the mobile thorax during backward bending - thoracolumbar region.

plane. The inferior motion of the inferior articular processes follows the curve of this convexity, and the result is an inferoposterior glide. Thus the arthrokinematic motion of the joint surfaces supports the osteokinematic motion of the vertebrae; posterior translation being coupled with backward sagittal rotation.

In the vertebrosternal region of the thorax, the posterior rotation of the neck of the rib results in an inferior glide of the tubercle at the costotransverse joint. The costotransverse joints of T3 to T7 are concavoconvex in both the sagittal and transverse plane, thus the inferior glide of the tubercle results in posterior rotation of the neck of the rib. Once again, the arthrokinematic motion supports the osteokinematic motion of the rib during backward sagittal rotation.

In the vertebrochondral region of the thorax (T8 - T10) the costotransverse joints are planar and oriented in an anterolateral and superior direction (Fig. 18). The anterolateroinferior glide of the tubercle does not induce a posterior rotation of the neck of the rib to the same degree as the middle and upper ribs (Fig. 36).

The first rib is always less mobile than T1 and the movement pattern is described below. In the thoracolumbar region, the eleventh and twelfth costovertebral joints are unmodified ovoid in shape and extension of the thoracic vertebra can be a pure spin (Fig. 37).

Stiffer thorax

The ribs are less mobile than the vertebral column when the stiffer thorax is extended. Initially, the anterior aspect of the rib travels superiorly and the posterior aspect travels inferiorly. Once the mobility of the rib cage is exhausted, the thoracic vertebrae con-

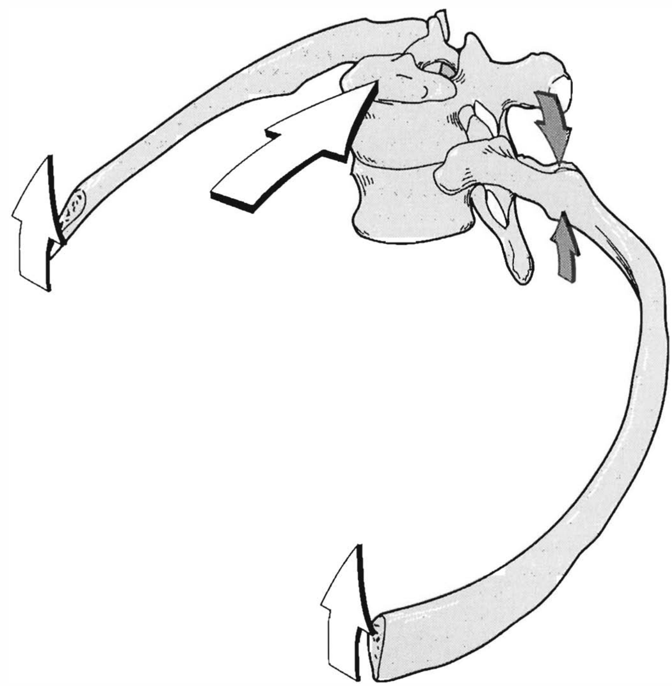


Figure 38.
The osteokinematic and arthrokinematic motion proposed to occur in the stiffer thorax during backward bending - vertebrosternal region.

tinue to extend on the stationary ribs (Figs. 38, 39). The arthrokinematics of the zygapophyseal joints remain the same as in the first movement pattern described, however, the degree of posterior translation is less. At the costotransverse joints, the arthrokinematics are different. As the thoracic vertebrae continue to extend, the concave facets on the transverse processes of T1 to T7 travel inferiorly relative to the tubercle of the ribs. The result is a relative *superior glide* of the tubercle of the rib at the costotransverse joint. In the vertebrochondral region, the facets of the costotransverse joints are planar and the relative glide of the rib is posteromedio-superior (Fig. 40).

Rigid thorax

When the relative flexibility between the vertebral column and the rib cage is the same, there is no palpable movement between the thoracic vertebrae and the ribs. Some inferior gliding occurs at the zygapophyseal joints, but very little anteroposterior translation occurs.

Limiting factors

All of the ligaments anterior to and including the posterior longitudinal ligament limit extension of the thoracic spinal unit. Panjabi et al[13] sequentially transected the anterior longitudinal ligament, the anterior half of the intervertebral disc, the costovertebral joints

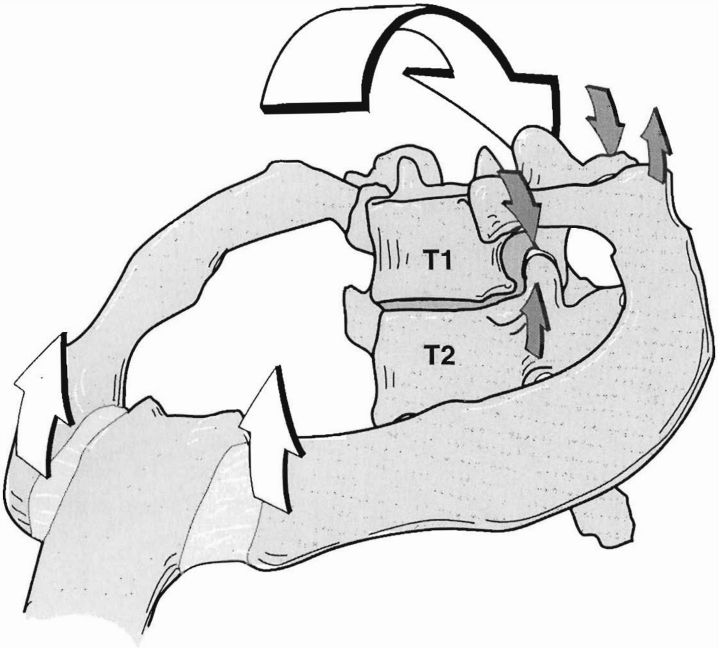


Figure 39.

The osteokinematic and arthrokinematic motion proposed to occur in the vertebromanubrial region during bilateral elevation of the arms.

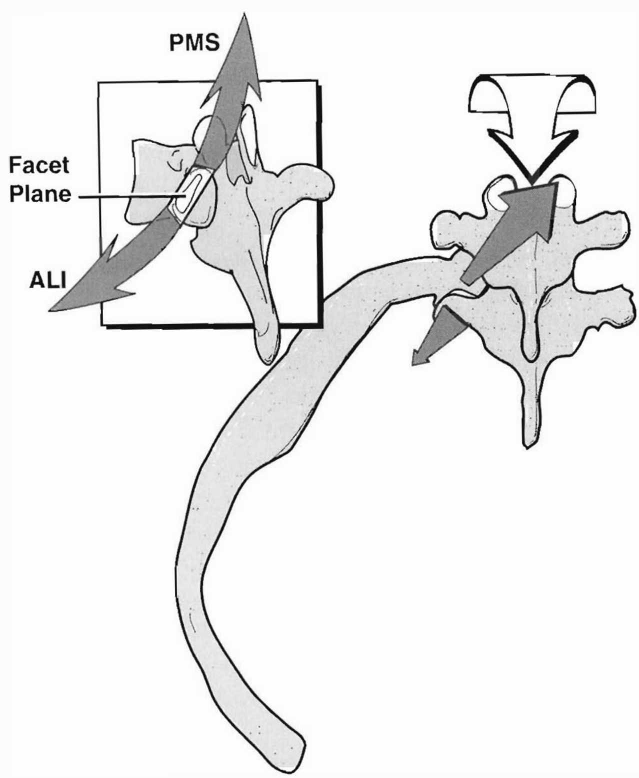


Figure 40.

The osteokinematic and arthrokinematic motion proposed to occur in the stiffer thorax during backward bending - vertebrochondral region.

and the posterior half of the intervertebral disc and noted the contribution of each to stability in extension. In extension, they found that the unit remained stable until the posterior longitudinal ligament was transected.

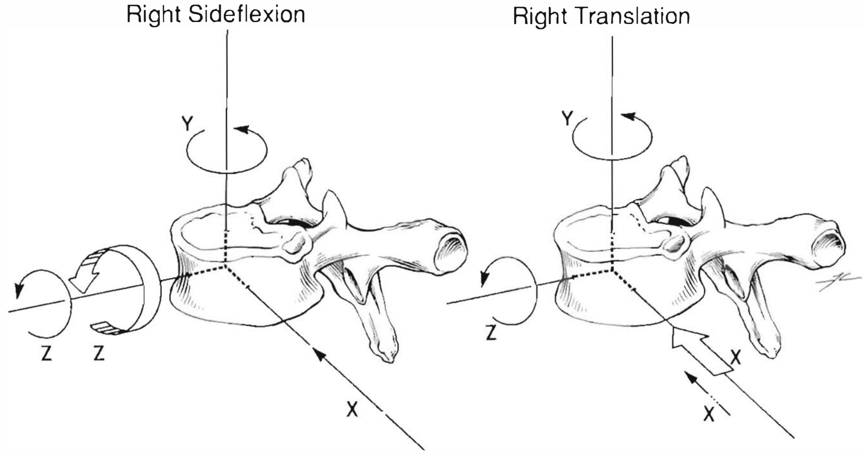


Figure 41.
Right sideflexion around the Z axis induced left rotation around the Y axis and right translation along the X axis. Right lateral translation along the X axis induced right sideflexion around the Z axis and left rotation around the Y axis. Redrawn from Panjabi, Brand and White[7]. From Lee[5,6] with permission.

Lateral bending

Sideflexion of the thoracic vertebrae occurs during lateral bending of the head and trunk. Panjabi et al[7] found that sideflexion, or rotation around the Z axis, was coupled with contralateral rotation around the Y axis and ipsilateral translation along the X axis (Fig. 41). Translation along the X axis was coupled with ipsilateral sideflexion around the Z axis and contralateral rotation around the Y axis.

It is interesting to postulate on what produces this coupling of motion in the thorax. In the midcervical spine, it is thought[2,14] that the oblique orientation of the zygapophyseal joints together with the uncinate processes directs the ipsilateral rotation which occurs with lateral bending of the head. In the lumbar spine, the zygapophyseal joints also are thought[15] to influence motion coupling. However, the facets of the zygapophyseal joints in the thoracic spine lie in a somewhat coronal plane and would not limit pure sideflexion during lateral bending of the trunk. It is difficult to see how they could be responsible for the contralateral rotation found to occur during sideflexion[7]. A clinical hypothesis of the factors which produce motion coupling during lateral bending of the thorax is proposed.

Clinical hypothesis

As the head and trunk bends laterally to the right, a left convex curve is produced. The thoracic vertebrae sideflex to the right, the ribs on the right approximate and the ribs on the left separate at their lateral margins (Fig. 42). In both the mobile thorax and the

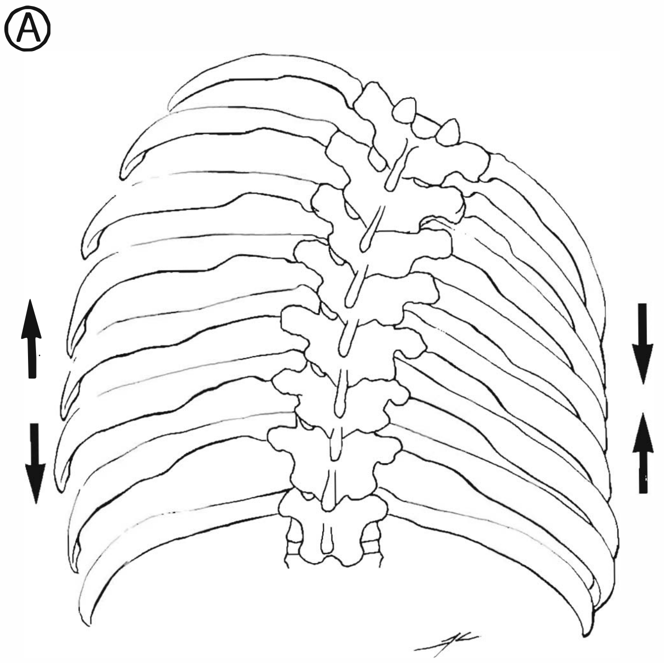


Figure 42.
As the thorax sideflexes to the right, the ribs on the right approximate and the ribs on the left separate at their lateral margins. The costal motion stops first, the thoracic vertebrae then continue to sideflex slightly to the right. From Lee[5, 6] with permission.

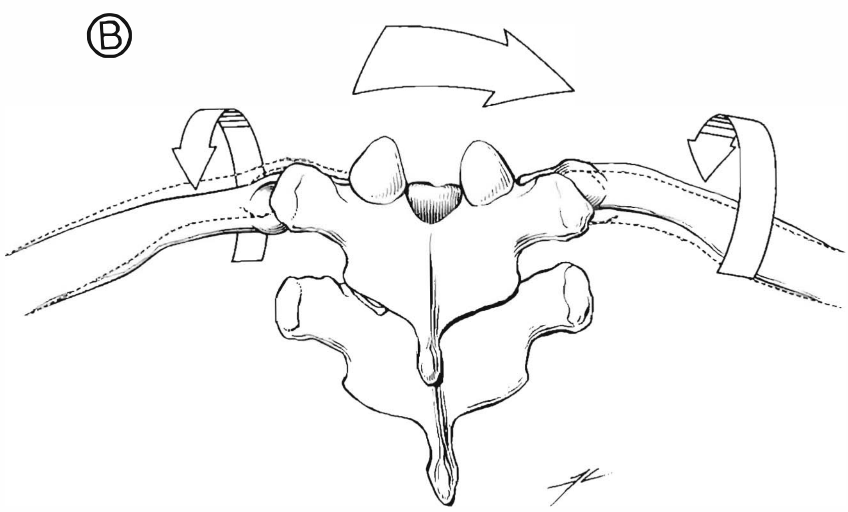


Figure 43.
In the vertebrosternal region, the superior glide of the right rib at the costotransverse joint induces anterior rotation of the same rib due to the curvature of the joint surfaces. The inferior glide of the left rib at the costotransverse joint induces posterior rotation of the same rib. From Lee[5,6] with permission.

stiffer thorax, the ribs appear to stop moving before the thoracic vertebrae. The thoracic vertebrae then continue to sideflex to the right. This motion can be palpated at the costotransverse joint.

In the vertebrosternal region (T3 to T7), this slight increase in right sideflexion of the thoracic vertebrae against the fixed ribs causes a relative superior glide of the tubercle of the right rib and a relative inferior glide of the tubercle of the left rib at the costotransverse joint (Fig. 43). Since the costotransverse joint is concavoconvex in

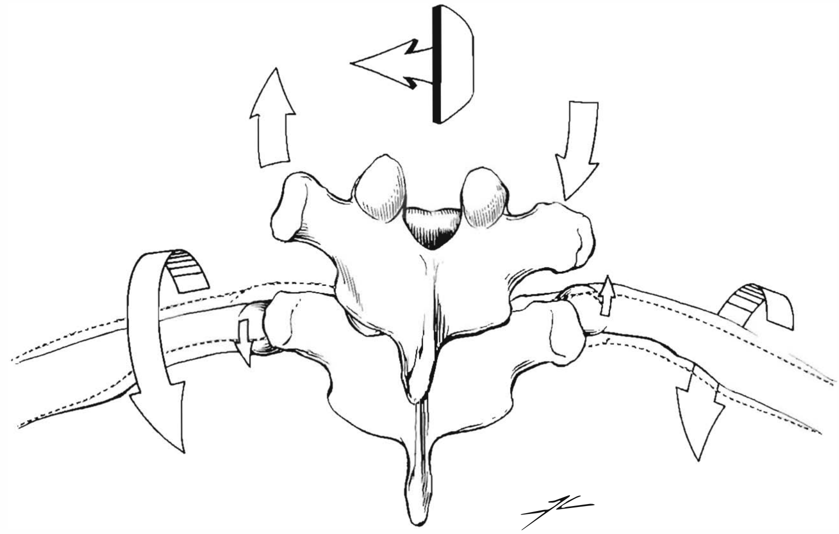


Figure 44.

In the vertebrosternal region, anterior rotation of the right rib and posterior rotation of the left rib facilitates a contralateral rotation of the superior vertebra due to the attachment of the rib to the inferior aspect of the superior vertebral body.

a sagittal plane, the superior glide of the right rib produces a relative anterior rotation of the neck of the rib with respect to the transverse process. The inferior glide of the left rib produces a posterior rotation of the neck of the rib relative to the transverse process. It is important to note that the moving bone is the thoracic vertebra, not the rib; however, the relative motion is described as though the rib was moving. Bilaterally, the effect of this rotation is to rotate the superior vertebral body to the left (contralateral to the sideflexion) (Fig. 44).

Panjabi, Brand and White[7] found that right lateral translation along the X axis (.5 - 1 mm) occurred during right sideflexion (Fig. 41). The effect of this right lateral translation is negated by the left lateral translation which occurs as the superior vertebra rotates to the left. The net effect is minimal, if any, mediolateral translation of the ribs along the line of the neck of the rib at the costotransverse joints. The clinical impression is that no anteromedial or posterolateral slide of the ribs (relative to the transverse process to which they attach) occurs during lateral bending of the trunk.

At the zygapophyseal joints, the left inferior articular process of the superior thoracic vertebra glides superomedially and the right process glides inferolaterally to facilitate right sideflexion and left rotation of the superior vertebra. The arthrokinematic motion of the joint surfaces supports the osteokinematic motion of the vertebrae and ribs.

In the vertebromanubrial region, the head of the first rib does not articulate with C7 and the superoinferior glide of the ribs and the conjunct rotation which occurs cannot influence the direction of

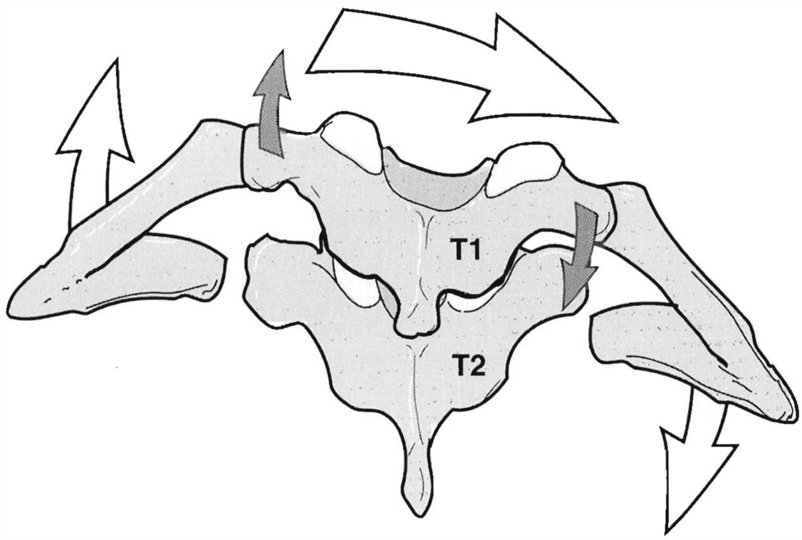


Figure 45.
The osteokinematic and arthrokinematic motion proposed to occur in the vertebromanubrial region during lateral bending of the head to the right.

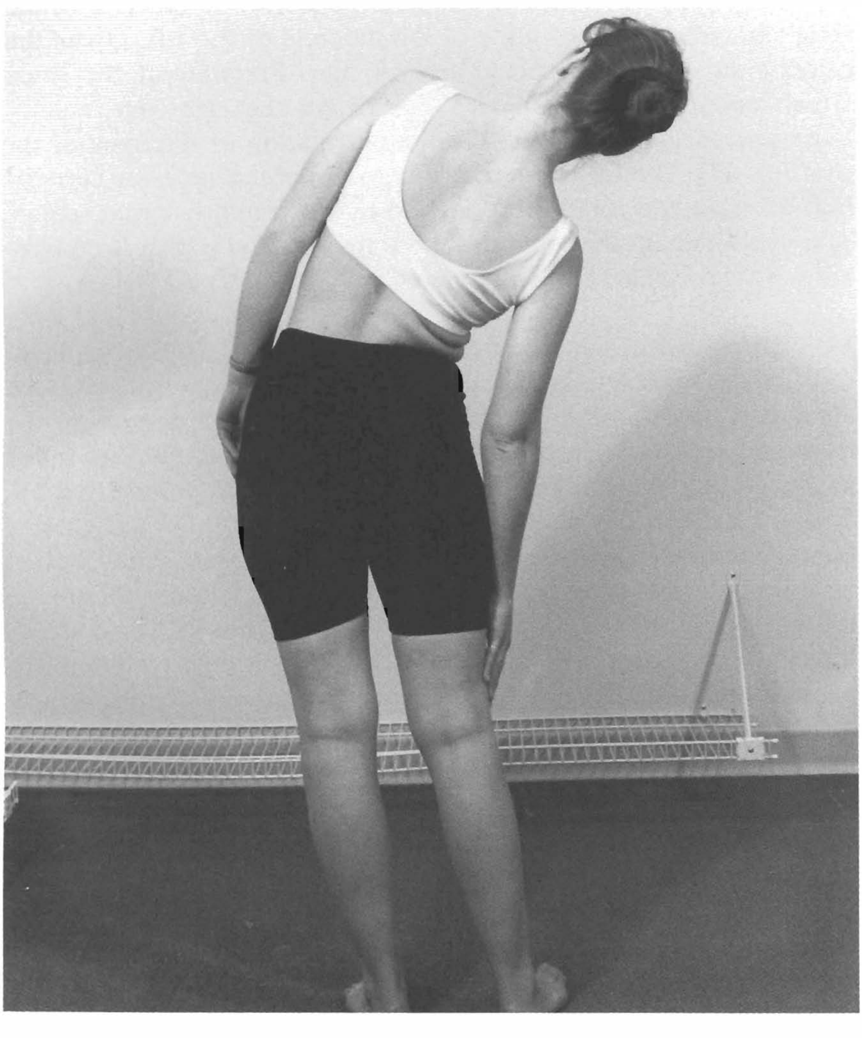


Figure 46.
Right lateral bending of the trunk with the apex at the left greater trochanter.

movement coupling between C7 and T1. C7-T1 and T1-T2 follow the same pattern of motion coupling as the midcervical spine when the head is bent laterally (Fig. 45). Sideflexion is coupled with ipsilateral rotation of the superior vertebra. The uncinate processes at C7-T1 may influence the direction of motion coupling here. During right lateral bending of the head/neck the transverse process glides inferiorly relative to the rib on the right and superiorly relative to the rib on the left.

The biomechanics of the vertebrochondral region during lateral bending of the trunk is dependant upon the apex of the curve produced in sideflexion. If the apex of the lateral bending curve is at the level of the greater trochanter on the left (Fig. 46), then all of the thoracic vertebrae sideflex to the right and the ribs approximate on the right and separate on the left. As the rib cage is compressed on the right and stops moving, further right sideflexion of the lower thoracic vertebrae results in a superior glide of the tubercle of the right rib and an inferior glide of the tubercle of the left. Given the orientation of the articular surfaces, the direction of the glide which occurs is posteromediosuperior on the right and anterolateroinferior on the left with minimal rotation of the neck of the rib (Fig. 47). The ribs do not appear to direct the superior vertebra into contralateral rotation as they do in the vertebrosternal region. The vertebrae are then free to follow the rotation which is congruent with the levels above and below.

If the apex of the lateral bending curve is within the thorax, (Fig. 48), then the osteokinematics of the lower thoracic vertebrae appear to be different. The rib cage remains compressed on the right and separated on the left, but the thoracic vertebrae sideflex to the left below the apex of the right lateral bending curve (i.e. T9, T10, T11, T12). Given the orientation of the articular surfaces of the costotransverse joints, the direction of the glide which occurs is anterolateroinferior on the right and posteromediosuperior on the left with minimal rotation of the neck of the rib. Once again, the ribs do not appear to direct the superior vertebra to rotate in a sense incongruent to the levels above and below.

At the thoracolumbar junction, pure sideflexion can occur (Fig. 49). The heads of the eleventh and twelfth ribs do not articulate with the vertebra above and there is no costotransverse joint to consider. The costovertebral joint shape is an unmodified ovoid and therefore pure sideflexion of the thoracic vertebrae between two fixed ribs can occur.

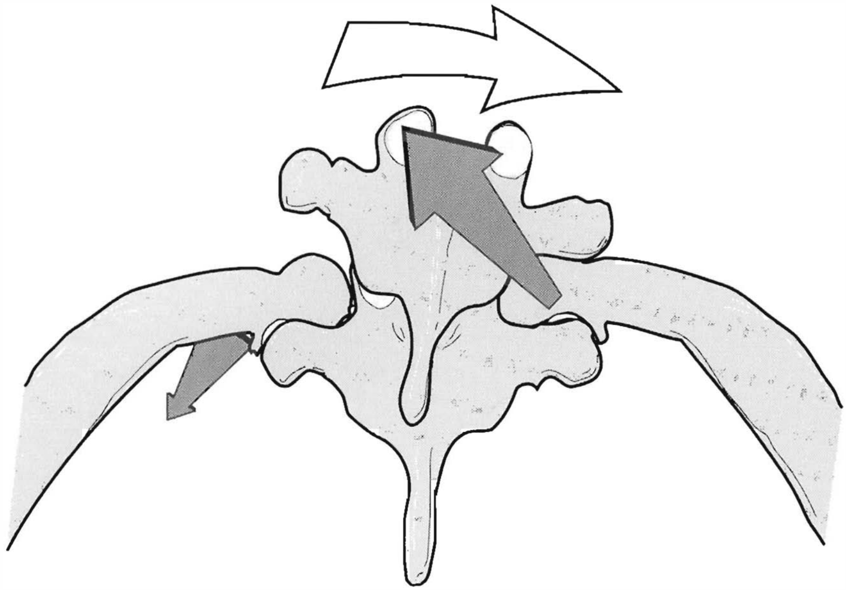


Figure 47.
The osteokinematic and arthrokinematic motion proposed to occur during right lateral bending of the vertebrochondral region. The direction of the arthrokinematic glide at the costotransverse joints is posteromediosuperior on the right and anterolateroinferior on the left. Minimal rotation of the head of the rib occurs since the costotransverse joint is planar. The rib, therefore, has little influence on the direction of motion coupling of the superior vertebra. The superior vertebra is free to follow the direction of rotation which is congruent with the levels above and below.

Figure 48.
Right lateral bending of the trunk with the apex within the thorax.

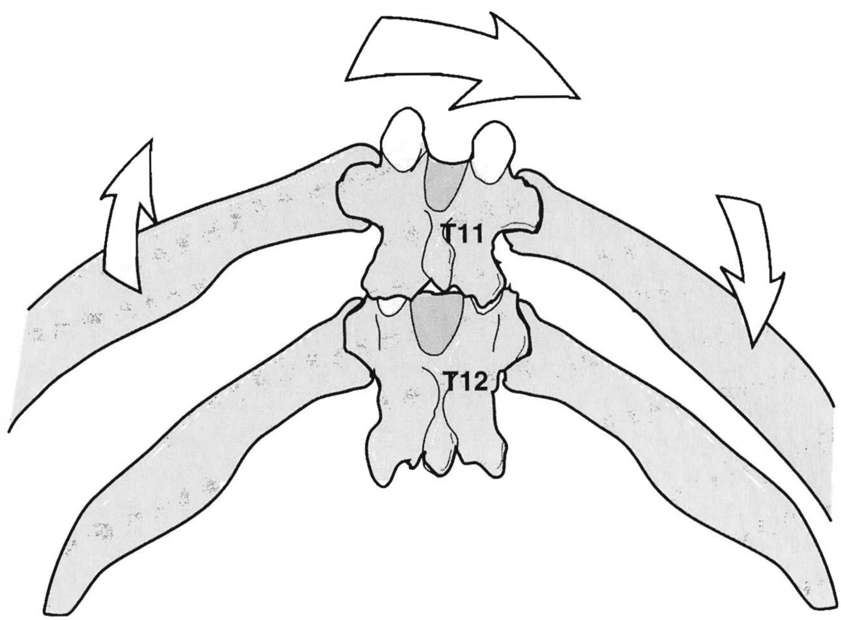


Figure 49.
The osteokinematic and arthrokinematic motion proposed to occur during right lateral bending of the thoracolumbar region.

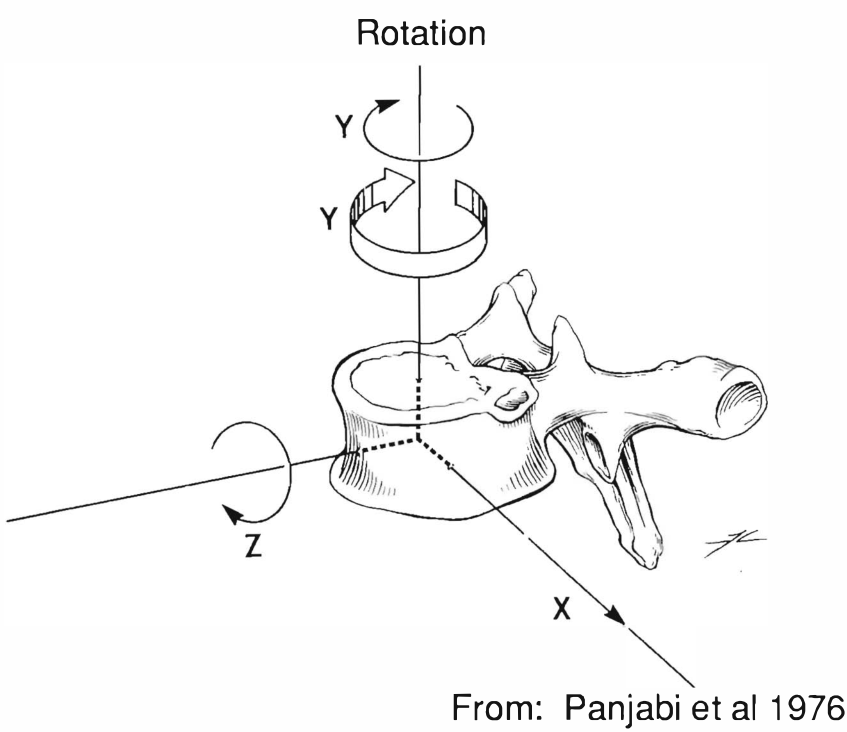


Figure 50.
Panjabi, Brand and White7 found that right rotation around the Y axis induced left sideflexion around the Z axis and left translation along the X axis. From Lee[5,6] with permission.

Rotation

Panjabi, Brand and White[7] found that rotation around the Y axis was coupled with contralateral rotation around the Z axis and *contralateral* translation along the X axis (Fig. 50). This is not consistent with clinical observation (Fig. 51). In both the vertebromanubrial and vertebrosternal regions, rotation around the Y axis

Figure 51.
Clinically, the midthorax appears to sideflex and rotate to the same side during rotation of the trunk.

has been found to be coupled with ipsilateral rotation around the Z axis and contralateral translation along the X axis. In other words, when axial rotation is the first motion induced, rotation and sideflexion occur to the same side. It may be that the thorax must be intact and stable both anteriorly and posteriorly for this in vivo coupling of motion to occur. The anterior elements of the thorax were removed 3 cm lateral to the costotransverse joints in the study by Panjabi et al[7].

When the anterior elements of the thorax are removed surgically, ipsilateral sideflexion and rotation cannot occur in the midthorax.

The costocartilage of the left sixth rib was removed for cosmetic reasons in the 17 year old youth illustrated in Figures 52 and 53. He presented four years later with persistent pain in the midthorax, and on examination of axial rotation he could not produce ipsilateral rotation/sideflexion of the midthoracic region.

Clinical hypothesis

During right rotation of the trunk the following biomechanics are proposed. The superior vertebra rotates to the right and translates to the left (Fig. 54). Right rotation of the superior vertebral body 'pulls' the superior aspect of the head of the left rib forward at the costovertebral joint inducing anterior rotation of the neck of the left rib (superior glide at the left costotransverse joint), and 'pushes' the superior aspect of the head of the right rib backward, inducing posterior rotation of the neck of the right rib (inferior glide at the right costotransverse joint). In the vertebrochondral region, the relative glide at the costotransverse joint is posteromediosuperior

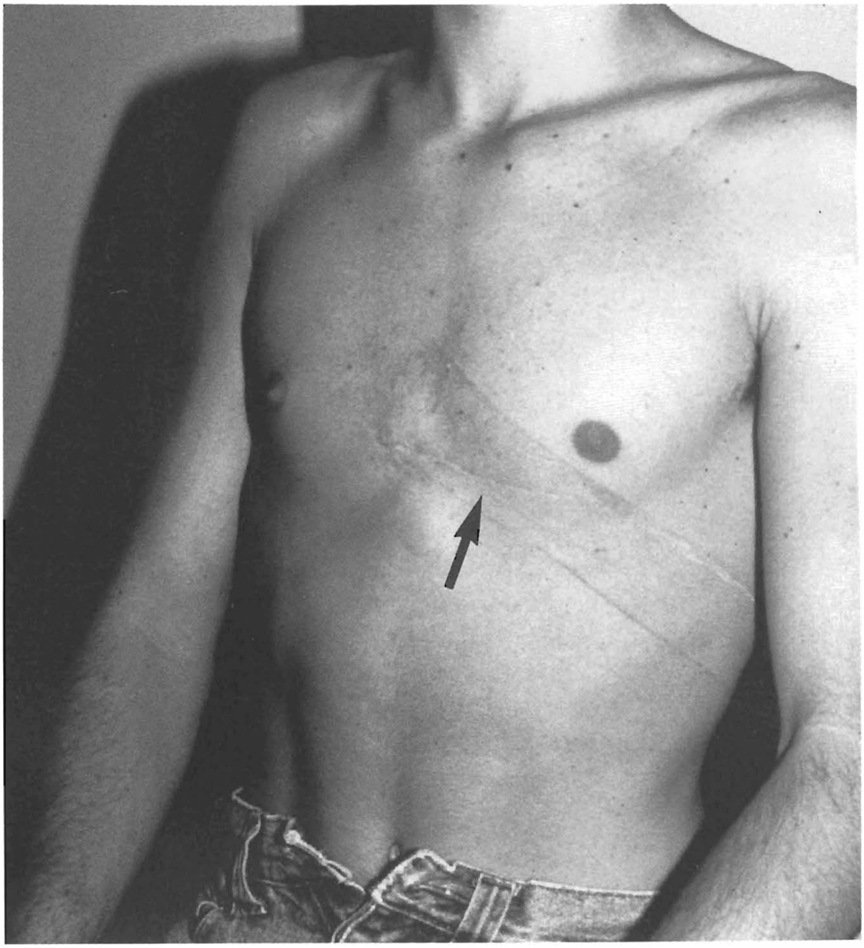


Figure 52.
The costocartilage of the left sixth rib was removed (arrow points to the incision) in this seventeen year old.

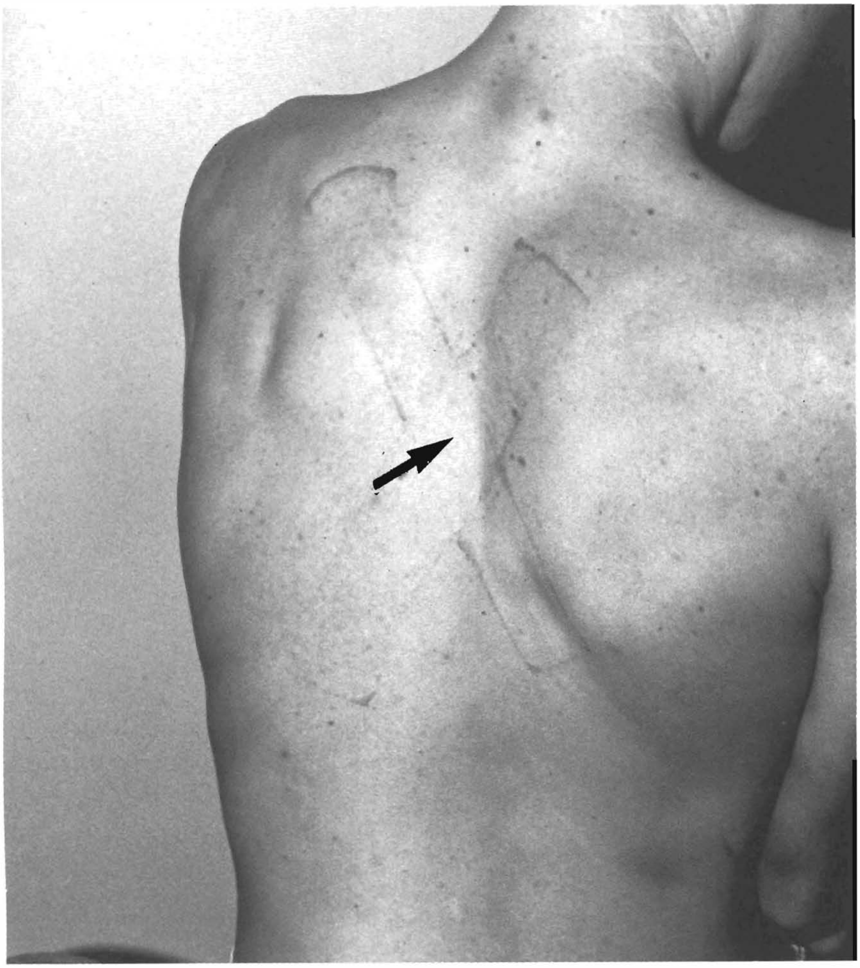


Figure 53.
Note the inability of the midthorax to rotate and sideflex to the right during right rotation of the trunk (arrow). Instability prevents the normal biomechanics of ipsilateral sideflexion/rotation during rotation of the trunk.

on the left and anterolateroinferior on the right (Fig. 55). The left lateral translation of the superior vertebral body 'pushes' the left rib posterolaterally along the line of the neck of the rib and causes a posterolateral translation of the rib at the left costotransverse joint. Simultaneously, the left lateral translation 'pulls' the right rib anteromedially along the line of the neck of the rib and causes an anteromedial translation of the rib at the right costotransverse joint. An anteromedial/posterolateral slide *of the ribs relative to the transverse processes to which they attach* is thought to occur during axial rotation.

When the limit of this horizontal translation is reached, both the costovertebral and the costotransverse ligaments are tensed. Stability of the ribs both anteriorly and posteriorly is required for the following motion to occur. Further right rotation of the superior vertebra occurs as the superior vertebral body tilts to the right (glides superiorly along the left superior costovertebral joint and inferiorly along the right superior costovertebral joint). This tilt

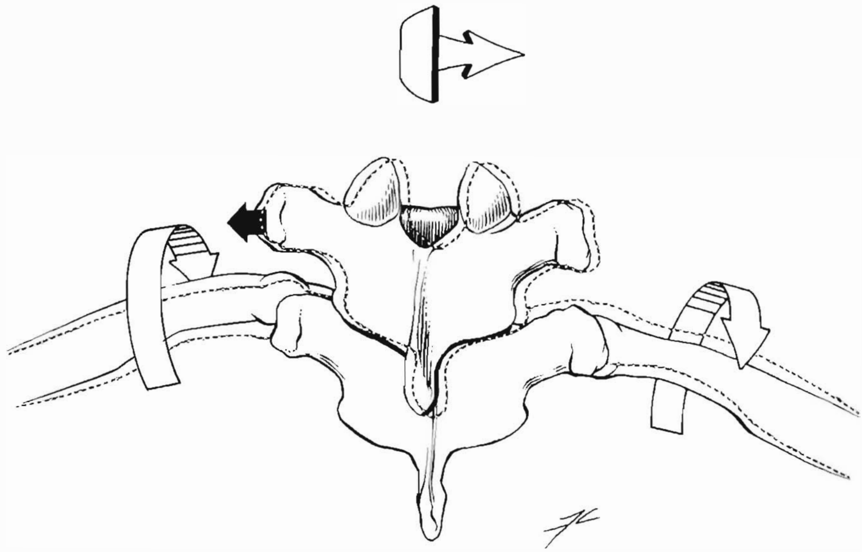


Figure 54.
The osteokinematic and arthrokinematic motion proposed to occur in the vertebrosternal region during right rotation of the trunk. From Lee[5, 6] with permission.

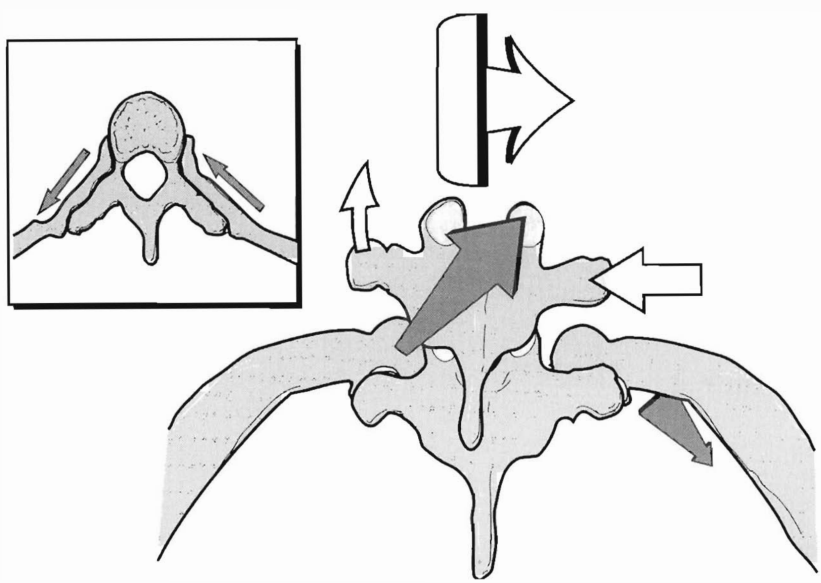


Figure 55.
The osteokinematic and arthrokinematic motion proposed to occur in the vertebrochondral region during right rotation of the trunk.

causes right sideflexion of the superior vertebra during right rotation of the midthoracic segment (Fig. 56).

At the zygapophyseal joints, the left inferior articular process of the superior vertebra glides superolaterally and the right inferior articular process glides inferomedially to facilitate right rotation and right sideflexion of the thoracic vertebra. The arthrokinematic motion of the joint surfaces supports the osteokinematic motion of the vertebrae and ribs.

In the vertebromanubrial region, C7-T1 and T1-T2 follow the same pattern of motion coupling as the midcervical spine when the

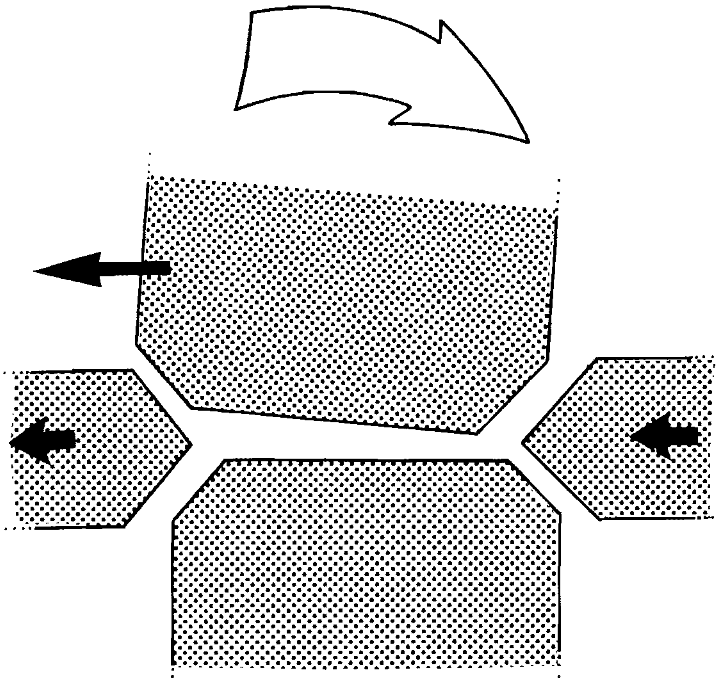


Figure 56.
At the limit of left lateral translation, the superior vertebra sideflexes to the right along the plane of the pseudo 'U' joint (analogous to the uncovertebral joint of the midcervical spine) formed by the intervertebral disc and the superior costovertebral joints. From Lee[5,6] with permission.

head rotated. Rotation is coupled with ipsilateral sideflexion of the superior vertebra. The two uncinate processes at C7-T1 may influence the direction of motion coupling here. During right rotation of the head/neck the transverse process glides inferiorly relative to the rib on the right and superiorly relative to the rib on the left (Fig. 45).

Considerable flexibility of motion coupling is apparent in the lower thorax. Anatomically, the lower thoracic levels (T10, T11) are designed to rotate with minimal restriction from the ribs. Passively, the T11-12 segment can be purely rotated about a vertical axis with no restriction from the zygapophyseal joints nor the ribs (Fig. 57). Actively, the coupled movement pattern for rotation in this region can be ipsilateral sideflexion or contralateral sideflexion. The coronally oriented facets of the zygapophyseal joints do not dictate a specific coupling of sideflexion when rotation is induced. The absence of a costotransverse joint and the lack of a direct anterior attachment of the associated ribs facilitates this flexibility in motion patterning at the eleventh and twelfth segments.

Respiration

The diaphragm is the most efficient respiratory muscle. However, contraction of the diaphragm can produce two different kinds of motion within the thorax.

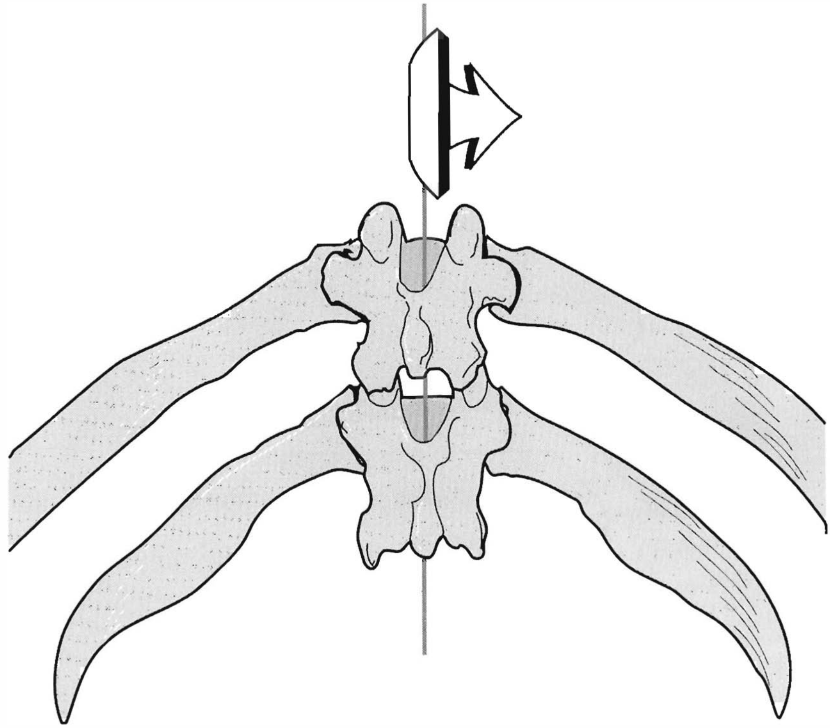


Figure 57.
The osteokinematic and arthrokinematic motion proposed to occur in the thoracolumbar region during right rotation of the trunk.

During inspiration, the diaphragm descends and pulls the central tendon inferiorly through the fixed twelfth ribs and L1 to L3. When the extensibility of the abdominal wall is reached, the central tendon becomes stationary and further contraction of the diaphragm results in posterior rotation of the lower six ribs. This posterior rotation causes torsion of the costocartilage anteriorly. If the costochondral and chondrosternal joints are stable, the torsional forces are transmitted anteriorly to the sternum.

As the ribs posteriorly rotate, the sternum is thrust in an anterosuperior direction thus increasing both the anteroposterior and vertical dimensions of the intrathoracic cavity. During full inspiration, this anterior thrust is also transferred to the manubrium. Since ribs one and two are shorter than ribs six and seven, the anterior manubrial displacement is less than the anterior sternal displacement. The manubriosternal symphysis accommodates this difference by bending in the sagittal plane (sternal flexion).

Alternatively, the diaphragm may contract through a stationary central tendon. The central tendon is the fixed point and produces the same osteokinematics as described above. There is no abdominal distension with this breathing pattern but rather lateral costal expansion.

Expiration occurs passively during relaxation of the diaphragm. Forced expiration requires recruitment from the anterior and posterior trunk musculature.

Regardless of the pattern of respiration, the arthrokinematics of the costotransverse joints remain the same. During inspiration, the tubercles of ribs one to seven glide inferiorly, ribs eight to ten glide anterolateroinferiorly and ribs eleven and twelve remain stationary. During expiration, the tubercles of ribs one to seven glide superiorly, ribs eight to ten glide posteromediosuperiorly and ribs eleven and twelve remain stationary. The arthrokinematics of the zygapophyseal joints is variable depending on the osteokinematic motion which occurs. During quiet respiration, very little motion is required from the zygapophyseal joints.

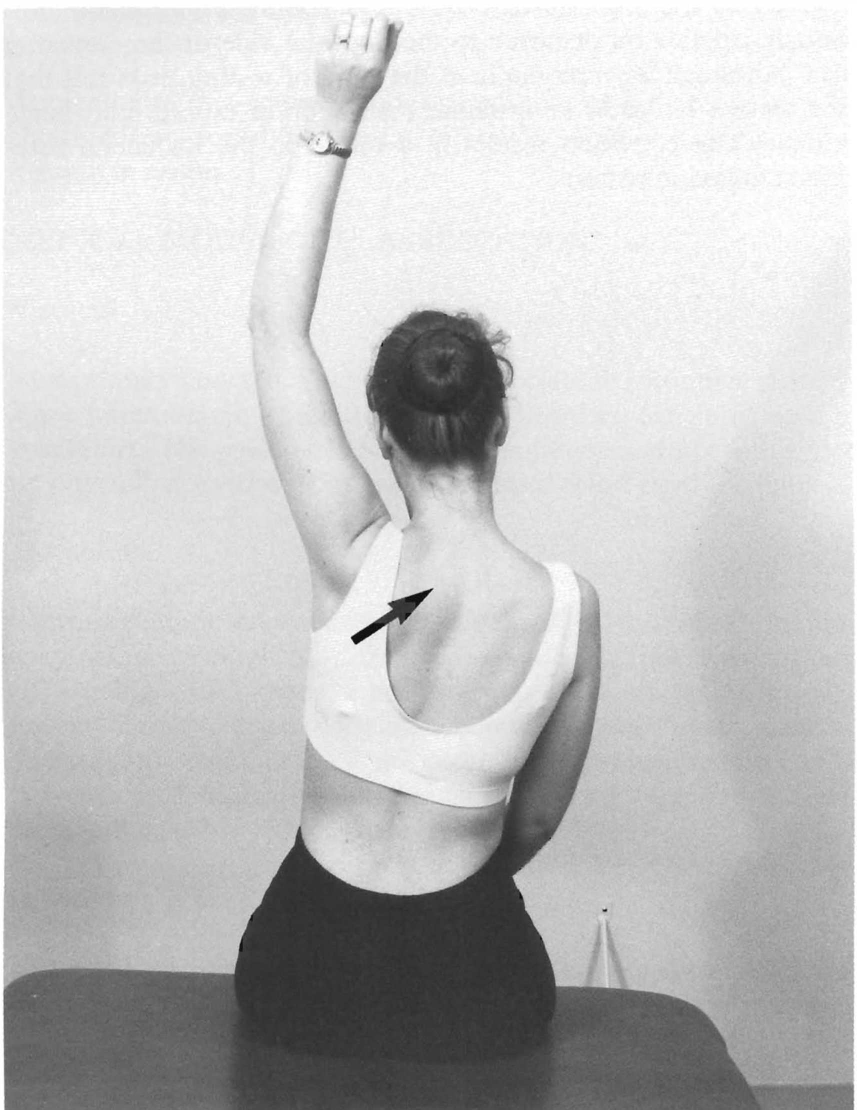


Figure 58.

During elevation of the left arm the vertebromanubrial region should produce a localized concavity on the side of the elevating arm.

Unilateral elevation of the arm

During unilateral elevation of the arm it has been noted that the vertebromanubrial region rotates, laterally bends and slightly extends to the side of the elevating arm (Fig. 58). The first two ribs posteriorly rotate on the same side and anteriorly rotate on the opposite. The specific arthrokinematics at the costotransverse joints depend upon relative flexibility between the thoracic vertebrae and the ribs. In a recent study by Stewart and Jull[16], the Fastrak 3-D Movement System was used to measure movement of the thoracic spine during unilateral elevation of the arm. The study confirmed that unilateral elevation of the arm did induce movement in the thoracic spine however, it was noted that the pattern of sideflexion and rotation was variable. In some asymptomatic individuals sideflexion occurred to the opposite side of the elevating arm. Although asymptomatic at the time of testing, it is felt that this pattern indicates an articular restriction or muscle imbalance which when corrected results in a return to the ipsilateral rotation/sideflexion pattern.

3
CONDITIONS

According to the medical model, conditions of the thorax may be classified as visceral, metabolic, infective, neoplastic, and spondylogenic in origin.

MEDICAL MODEL OF CLASSIFICATION

Visceral

As a primary contact clinician, it is important to recognize that primary intrathoracic and intraabominal disorders can refer pain to the thorax. The pain tends to be dull and deep and not influenced by physical activities. Rest may not afford relief from the pain.

Metabolic

Some metabolic conditions which can effect the thorax include ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis (DISH Fig. 59), rheumatoid arthritis, osteoporosis (Fig. 60), fibromyalgia, ochronosis, gout, tuberculosis and Paget's disease. Although manual therapy is not contraindicated when these conditions are present, the clinician must modify the intensity of treatment and possibly reduce the expected outcome.

Infection

Bacterial and viral infections can occur within the skeletal components of the thorax. The patient usually feels systemically unwell and the characteristics of the pain behaviour should alert the clinician to suspect a nonmechanical source of pain. Essentially, systemic inflammatory and/or infective disorders affecting the thorax

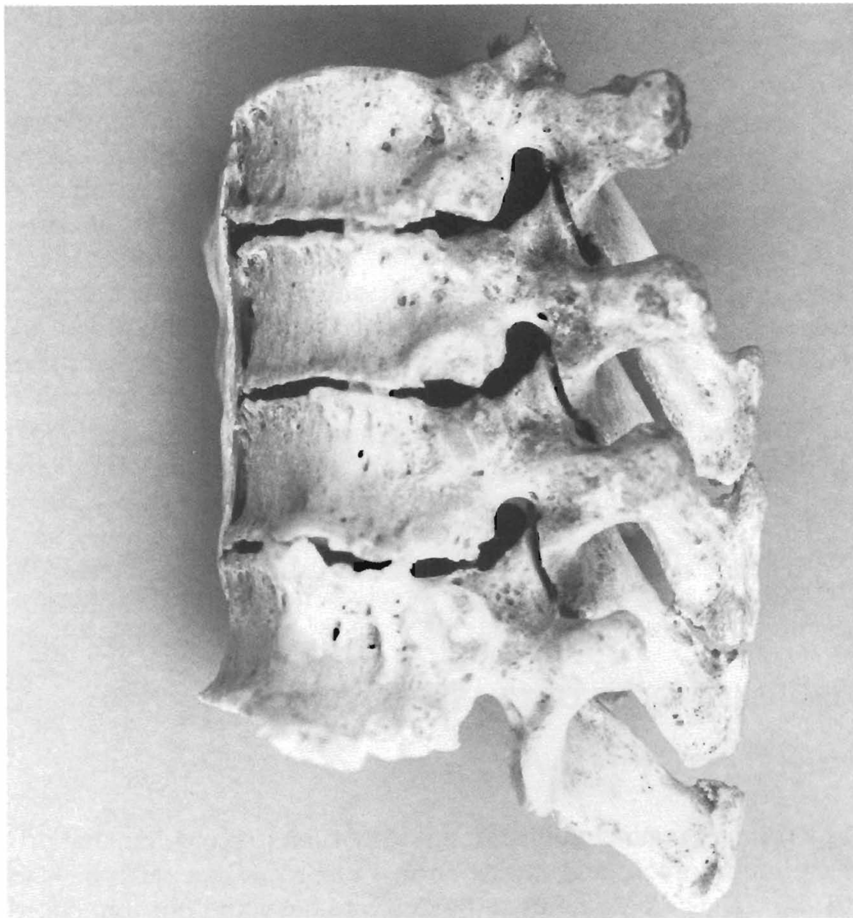


Figure 59.
Ossification of the longitudinal ligaments of the spine occurs with diffuse idiopathic skeletal hyperostosis.

can be differentiated from traumatic inflammation (i.e. sprain) by the lack of trauma in the history, the inconsistent response of the joint to mechanical stress and rest as well as the lack of resolution with appropriate therapy over a short period of time. The experienced clinician will quickly recognize the pattern of response to therapy which deviates from the norm and question the etiology at this point. Subsequent investigation is then indicated.

Neoplastic

Both benign and malignant tumours can occur in the skeletal components of the thorax. Secondary metastases are common from the lung and breast and a past history of carcinoma should alert the clinician to this possibility.

Spondylogenic

Spondylosis includes any dysfunction of the musculoskeletal system secondary to major or minor trauma. Degenerative changes are included here.

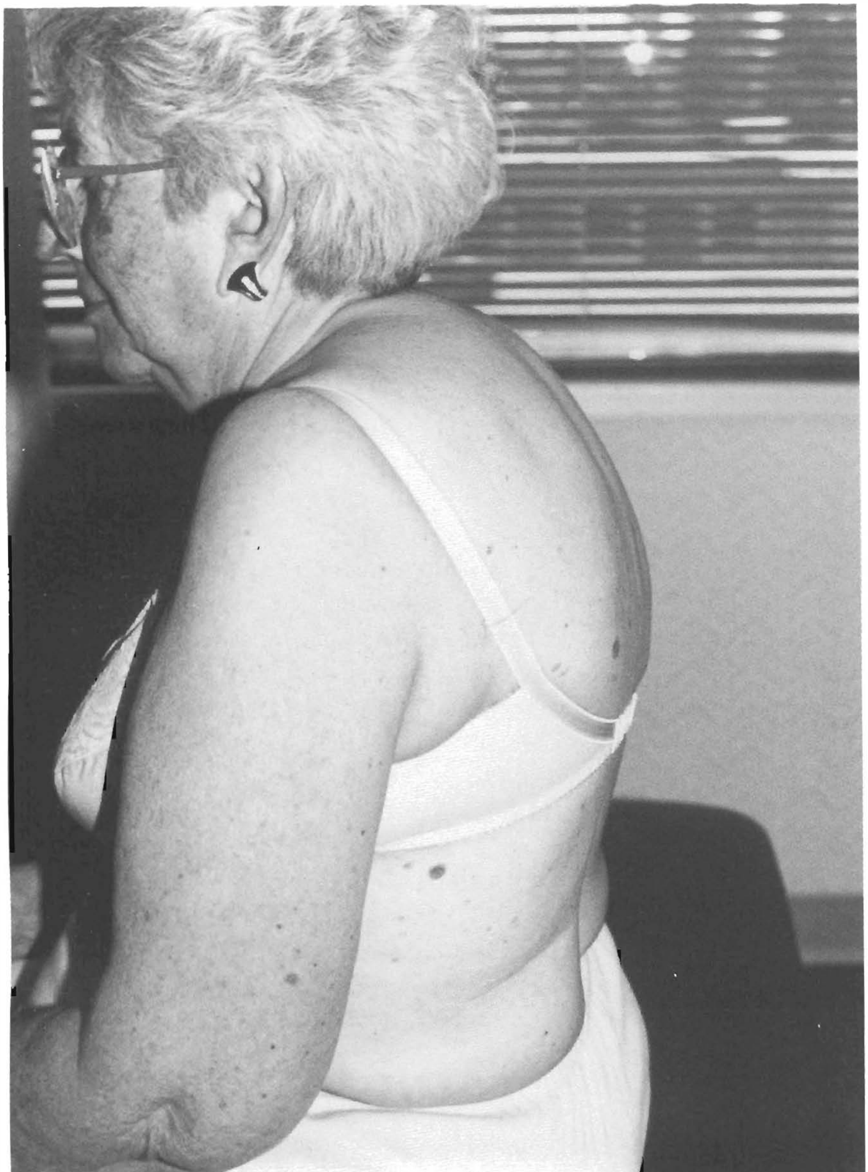


Figure 60.
The typical posture of a patient with advanced osteoporosis.

Scoliosis is a complex, multifactorial problem of both known and unknown causes (Fig. 61). It may be congenital or acquired; from disease or injury. It has long been recognized[17] that idiopathic scoliosis involves muscle imbalance. Henry Kendall (1930) noted that

> "The muscle weakness was almost always found in the lateral abdominals, anterior abdominals, pelvic, hip and leg muscles. This weakness caused the body to deviate from either the lateral median plane or the anterior-posterior median plane, causing the patient to compensate for the deviation by substituting other muscles in order to

Figure 61.
This patient has a marked thoracolumbar scoliosis secondary to poliomyelitis.

maintain equilibrium. In doing the substituting, the patient invariably develops muscles which cause lateral rotatory movements and it is easy to see why we have lateral curvature with rotation."[17]

However, even the most compliant patient and diligent therapist cannot prevent the progression of some scoliotic curves with exercise. Current research on the etiology of idiopathic scoliosis has revealed a possible central processing or neural component[18,19]. The reader is referred to Kendall[17] for the evaluation and treatment of muscle imbalances of the trunk and lower extremities and to the referenced material for further information on the neural basis of idiopathic scoliosis.

MANUAL THERAPY MODEL OF CLASSIFICATION

Although the medical model of classification is useful for understanding the etiology of pain, classifications which follow a biomechanical model based on mobility and stability are more useful for the manual therapist. In keeping with this model, disorders within the thorax can be classified into three groups, each of which describes the objective findings noted on mobility testing and suggests the appropriate treatment. They include:

1. Hypomobility with or without pain

2. Hypermobility with or without pain

3. Normal mobility with pain

This classification does not provide a specific anatomical nor physiological cause for the aberrant mobility noted, however, since manual therapy techniques are specific to restoring movement patterns, the cause is not required for formulating treatment plans. The aim of all evaluation procedures is to identify the system (i.e. articular, myofascial, neural) which is effecting function. Treatment can then be modified to either mobilize or stabilize the appropriate system. If the biomechanics are restored and *if* the underlying etiology is biomechanical in nature, symptomatic and objective improvement usually follows.

The principles upon which treatment is based follow those of the body's natural healing process. One of the goals of therapy is to facilitate the natural process by preventing or reversing the factors which tend to retard recovery.

Long ago when living organisms were unicellular, death of the cell meant death of the organism. With the evolution of multicellular organisms, came the process of repair following injury. Subsequently, this repair process was perfected such that complete regeneration of a limb was possible after amputation. Lizards and newts have retained this capability today. Unfortunately, the evolution of more complex life forms (i.e. the mammal) has occurred at the expense of such total regenerative abilities. The cardiac muscle in man does not regenerate following infarction, neural tissue does not regenerate following cellular death, skin does not regenerate following full thickness injury and an amputated finger does not grow back. With few exceptions, mammalian tissue responds to injury by repair rather than regeneration.

Repair occurs by fibrous proliferation regardless of which tissue has been damaged. The process can be divided into three phases - substrate, fibroblastic and maturation. Treatment varies according to the stage of tissue repair.

HEALING PROCESS

Substrate phase

The substrate phase extends from the time of injury to the fourth to sixth day and is characterized by the inflammatory response. The inflammatory reaction prepares the wound for subsequent healing by removing necrotic tissue and bacteria. At the same time, fibroblasts migrate to the wound site. The wound is very weak at this time since it is only the gluing action of fibrin, which has a very low breaking strength, which holds the wound edges together.

Fibroblastic phase

The fibroblastic phase lasts up to four to ten weeks post trauma[20]. Manual therapy has its greatest influence during this time when the proliferating fibroblasts begin to synthesize collagen, mucopolysaccharides and glycoproteins. Fibroblasts repair the wounded tissue by replacing it with fibrous tissue. Tropocollagen is secreted from the fibroblasts and quickly aggregates into collagen fibres. The orientation of the fibres can be influenced by mechanical forces at the wound site[20]. The tensile strength of the wound at this time is proportional to the quantity of collagen present as opposed to crosslinking between the collagen fibres.

Maturation phase

There is no sharp demarcation between the end of the fibroblastic phase and the beginning of the maturation phase. The quantity of collagen within the wound remains static between the third and fourth weeks although the wound continues to gain in tensile strength. This strength gain is due to crosslinking and remodelling of the collagen fibres to give a stronger weave. The quantity of collagen is in equilibrium, however, the organization is undergoing change. This process of remodelling may require six to twelve months for completion[20].

Clinical application to treatment

Scar tissue can create pain and disability within the musculoskeletal system depending on how the repaired tissue differs from that it replaces. Essentially, the repair process restores the structure with little regard to function. For example, collagen is non-contractile and when it repairs a torn muscle, both the contractility and extensibility of the muscle will be effected. The aim of treatment, therefore, must be to control and to guide the repair process such that *optimal* structure and function are restored.

In the substrate and the early fibroblastic stage, vigorous exercise programs or aggressive passive mobilizations are contra-indicated since there is minimal crosslinking of collagen fibres. Gentle passive mobilizations and exercises within the painfree range of motion will facilitate the proper orientation of collagen deposition at the wound site. The patient will find that the best resting position for acute thoracic pain is semi-sitting. Supine lying on a hard surface forces the thorax into an extended posture while sidelying often induces sideflexion and rotation.

Organized, restrictive adhesions can develop during the maturation phase of tissue repair if the range of motion is not restored within the fibroblastic phase. While the structure may be restored, function may be adversely effected by the adhesion. More vigorous mobilization techniques and frequent exercises at home will be required to facilitate a return of the range of motion.

Left alone, wounded tissue will repair. The efficacy of the repair process depends on how well the replacement tissue restores the tissue's original function. The role of therapy is to guide the deposition and remodelling of the scar at each stage of repair such that the resultant structure will subserve the tissue's function. To successfully achieve this goal, it is paramount that the patient become involved in their own rehabilitation through home exercise programs which follow the principles of tissue healing.

4

ASSESSMENT

When a consistent approach to assessment is followed, the patterns of mechanical dysfunction of the thorax emerge. The purpose of this section is to outline the basic subjective and objective examination.

Table I. Subjective examination

Name: Age: Dr:

Current History (mode of onset):

Past History: Past Treatment:

PAIN/DYSAESTHESIA

Location: Relieving/Aggravating Activities:

Special Questions: Distal paraesthesia, Bowel/bladder
Effect of sustained SLUMP and/or neck flexion

SLEEP

Surface/Position: Status in a.m.:
Night wakening:

GENERAL INFORMATION

Occupation/sport/hobbies:

General Health: Medication:

Results of adjunctive tests:

SUBJECTIVE EXAMINATION

The answers to the subjective examination indicate the nature, irritability and severity of the presenting problem.

Mode of onset

Was the onset of symptoms sudden or insidious? Was there an element of trauma? If so, was there a major traumatic event over a short period of time, such as a motor vehicle accident, or was there a series of minor traumatic events over a long period of time. Is the patient presenting during the substrate, fibroblastic or maturation phase of healing? Is this the first episode requiring treatment or is this a recurring problem?

Pain/dysaesthesia

Where is the pain and/or dysaesthesia? Is it localized or diffuse? Where does it radiate to and can it's quality be described? If there is symptom referral, does it tend to refer around the chest or through the chest? What activities, if any, aggravate the symptoms? How long does it take for this activity to produce symptoms? Which activities (including how much) provide relief?

Sleep

Are the symptoms interfering with sleep? What kind of bed is being slept in and what position is most frequently adopted? Does rest provide relief?

Occupation/leisure activities/sports

What level of physical activity does the patient consider their normal and essential for return to full function? What are the patient's goals from therapy?

General information

How is the patient's general health? Is any medication being taken for this or any other condition? What are the results of any adjunctive diagnostic tests (i.e. X-rays, CT scan, MRI, laboratory tests)?

Table II. Objective examination

Postural Analysis

Habitual movement tests

Forward and backward bending
Lateral bending
Axial rotation
Respiration
Combined movement testing
Unilateral elevation of the arm

Articular function

Active/passive mobility tests of osteokinematic function
- *Forward bending*
- *Backward bending*
- *Lateral bending*
- *Rotation*
- *Respiration*

Passive mobility tests of arthrokinematic function
- *Zygapophyseal joints*
- *Costotransverse joints*
- *Mediolateral translation*

Passive stability tests of arthrokinetic function
- *Vertical (traction/compression)*
- *Anterior translation - spinal*
- *Posterior translation - spinal*
- *Transverse rotation - spinal*
- *Anterior translation - posterior costal*
- *Inferior translation - posterior costal*
- *Anterior/Posterior translation - anterior costal*
- *Superior/Inferior translation - anterior costal*
- *Mediolateral translation*

Muscle function

Nerve function

Adjunctive tests

Postural Analysis

Deviation of the thorax from the three cardinal body planes is common and not necessarily associated with symptoms. However, mechanical dysfunction often presents with postural deviation and therefore, postural analysis in relation to the sagittal, coronal and transverse body planes is essential.

In the sagittal plane, a vertical line should pass through the external auditory meatus, the bodies of the cervical vertebrae, the glenohumeral joint, slightly anterior to the bodies of the thoracic vertebrae transecting the vertebrae at the thoracolumbar junction, the bodies of the lumbar vertebrae, the sacral promontory, slightly posterior to the hip joint and slightly anterior to the talocrural joint and naviculo-calcaneo-cuboid joint.

In the coronal plane, the clavicles should be horizontal, the manubrium and sternum vertical and the scapulae should rest such that the medial border is parallel to the thoracic spine with the inferior angle approximated to the chest wall. Deviations of the spinous processes are common and often insignificant. The resting tone of the muscles of the back should be noted.

Habitual movement tests

These tests examine the habitual movement patterns of the head and trunk. The quantity and quality of available motion as well as the presence/location of evoked symptoms are noted. The results of these tests alone are not sufficient to diagnose a local dysfunction. They are used as screening tests to localize further mobility testing.

Forward and backward bending

With the patient standing or sitting he/she is instructed to forward bend the head/trunk and the quantity and symmetry of motion is observed (Figs. 62, 63). Neither rotation nor sideflexion should occur during forward bending and if present requires further specific mobility testing. Backward bending of the vertebromanubrial region is achieved by asking the patient to elevate their arms bilaterally (Fig. 64). When examining backward bending of the vertebrosternal and vertebrochondral regions of the thorax (Fig. 65), it is critical to note that the region being examined is actually backward bending. Some movement modification may be required to ensure that the motion being performed correctly.

Figure 62.
Habitual movement testing - forward bending of the head.

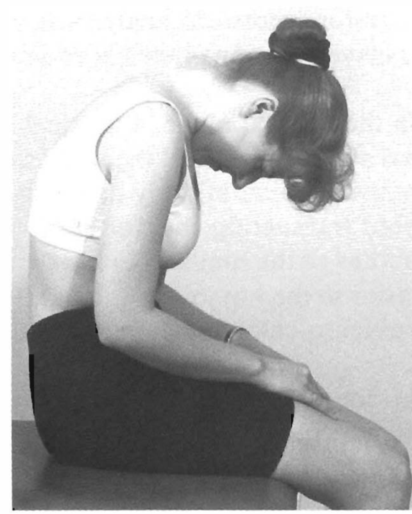


Figure 63.
Habitual movement testing - forward bending of the trunk.

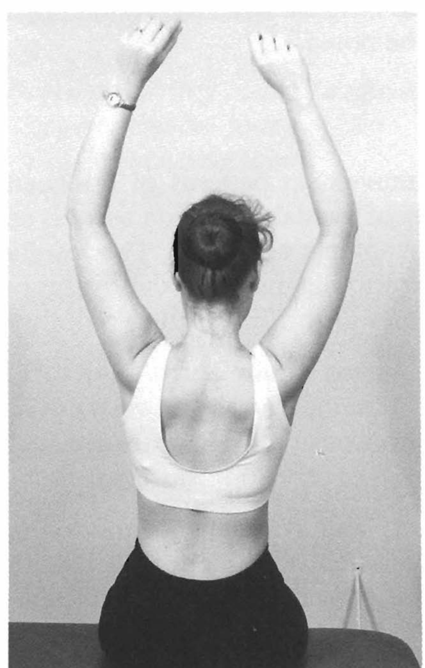


Figure 64.
Habitual movement testing - backward bending of the vertebromanubrial region occurs during bilateral elevation of the arms.

Figure 65.
Habitual movement testing - backward bending of the trunk.

Lateral bending (Figs. 66, 67, 68)

With the patient standing or sitting he/she is instructed to laterally bend the head/trunk to either side. The ability of the thorax to produce a smooth regional curve is noted. A flat region or a kink in the

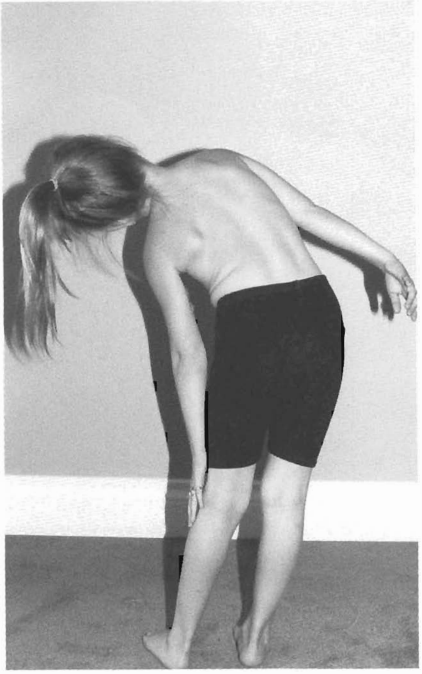


Figure 66.

Habitual movement testing - lateral bending of the head.

Figure 67.

Habitual movement testing - lateral bending of the trunk. Note the flexibility of the 6 year old child.

Figure 68.

Habitual movement testing - lateral bending of the trunk. Note the rigidity of the 71 year old adult.

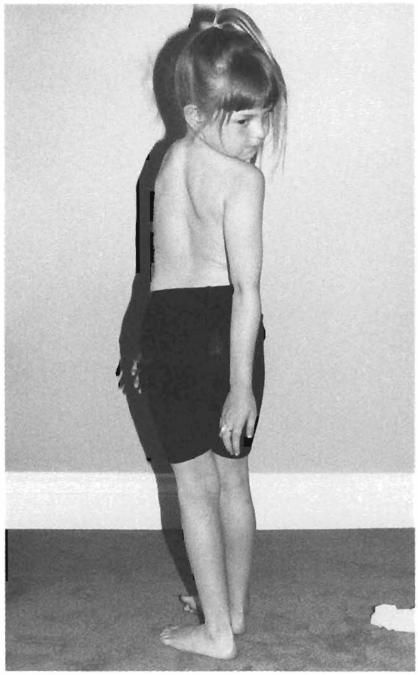
Figure 69.

Habitual movement testing - rotation of the trunk should produce a smooth S curve.

curve requires further specific mobility testing to determine the cause.

Axial rotation (Figs. 69, 70, 71)

With the patient standing or sitting he/she is instructed to rotate the



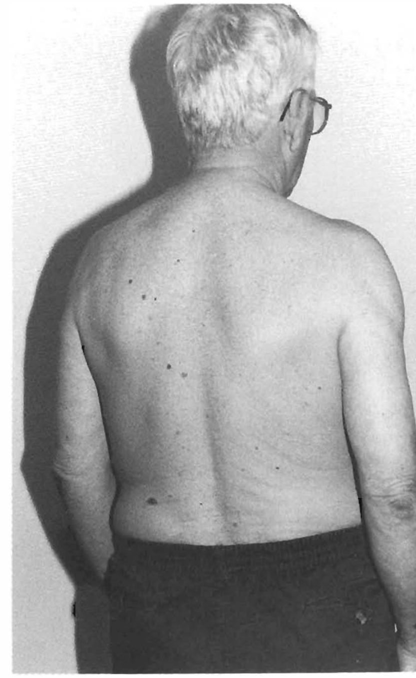


Figure 70.
Habitual movement testing - rotation of the trunk. Note the flexibility of the 6 year old child.

Figure 71.
Habitual movement testing - rotation of the trunk. Note the rigidity of the 71 year old adult.

Figure 72.
Habitual movement testing - respiration.

Figure 73.
Habitual movement testing - respiration.

head/trunk to either side. The ability of the thorax to produce a smooth regional S curve is noted. A lack of movement or a kink in the curve requires further specific mobility testing to determine the cause.

Respiration (Figs. 72, 73)

With the patient standing or sitting he/she is instructed to take a deep breath in and a long breath out. Any asymmetry of chest expansion and release is noted and when present requires further specific mobility testing to determine the cause.

Combined movement testing

Hypomobile joints present a consistent clinical picture when combined movements are tested. With the patient standing or sitting he/she is instructed to:

1. forward bend the head/trunk and then right lateral bend the head/trunk.

2. forward bend the head/trunk and then left lateral bend the head/trunk.

3. backward bend the head/trunk and then right lateral bend the head/trunk.

4. backward bend the head/trunk and then left lateral bend the head/trunk.

Any restriction to movement or kinks in the curve are noted. The response to these combined movements can be charted on the letter I. The forward/backward bending component of the motion is denoted by the vertical band of the I and the lateral bending component by the horizontal band. When an abnormal movement pattern is detected, an X is placed on the 'arm' of the I which manifested the abnormal pattern. For example, when a zygapophyseal joint is restricted in superior gliding on the left, an abnormal movement pattern will be detected on forward bending combined with right lateral bending. This is charted by placing an X over the right top horizontal band of the letter I.

The patient is then instructed to:

4. right lateral bend the head/trunk and then forward bend the head/trunk.

5. left lateral bend the head/trunk and then forward bend the head/trunk.

6. right lateral bend the head/trunk and then backward bend the head/trunk.

7. left lateral bend the head/trunk and then backward bend the head/trunk.

Any restriction to movement or kinks in the curve are noted. The response to these combined movements can be charted on the letter H. The forward/backward bending component of the motion is denoted by the vertical band of the H and the lateral bending component by the horizontal band. When an abnormal movement pattern is detected, an X is placed on the 'arm' of the H which manifested the abnormal pattern. For example, when a zygapophyseal joint is restricted in superior gliding on the left, an abnormal movement pattern will be detected on right lateral bending combined with forward bending. This is charted by placing an X over the right top vertical band of the letter H.

A hypomobile joint is consistent in that an abnormal movement pattern is detected in the same 'arm' of the H and I tests. It does not matter which movement is induced first, lateral bending or forward bending, the abnormal motion shows up in both. Hypermobile joints are inconsistent in the pattern they present. An abnormal movement pattern may occur when forward bending occurs first but not when lateral bending is the initial motion.

Unilateral elevation of the arm

Unilateral elevation of the arm is useful in evaluating the combined movements of the vertebromanubrial region. The upper thorax should rotate and sideflex to the side of the elevating arm and thus produce a very localized C curve concave towards the elevating arm. The first two ribs should posteriorly rotate on the same side and anteriorly rotate on the opposite.

Articular function

When a mobility abnormality is detected during the habitual movement tests, further examination is required to determine the etiology. The specific segmental tests of osteokinematic and arthrokinematic function are used to differentiate an intra-articular from a myofascial cause for the abnormal motion noted. They include active physiological mobility tests, passive physiological mobility tests and passive accessory mobility tests. The active physiological mobility tests examine the osteokinematics of a functional spinal and costal unit which includes two adjacent thoracic vertebrae, the two ribs which attach to these vertebrae and the manubrium/sternum. The passive physiological mobility tests provide further information on the end feel of motion. The passive accessory

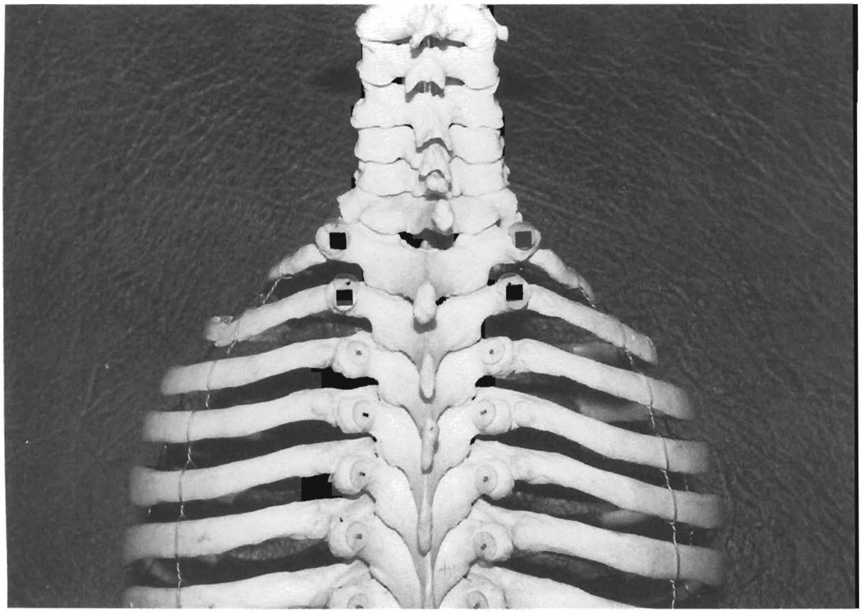


Figure 74.

Active mobility tests of osteokinematic function - points of palpation for T1-2.

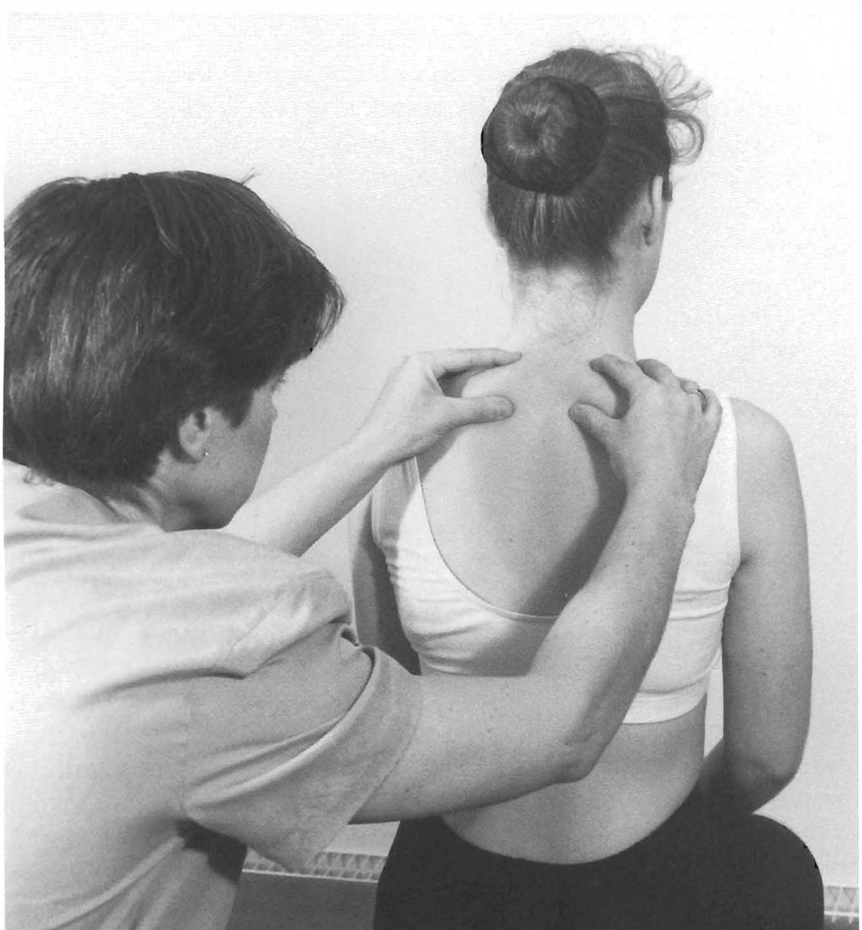


Figure 75.

Active mobility tests of osteokinematic function - palpation for flexion of T1-2.

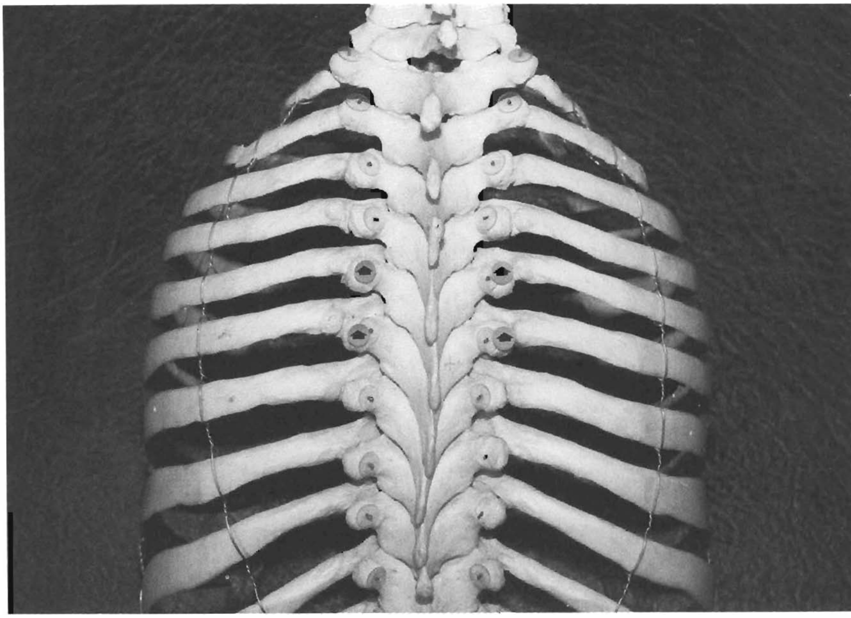


Figure 76.
Active mobility tests of osteokinematic function - points of palpation for T5-6.

mobility tests examine the arthrokinematic function of the zygapophyseal joints, the costotransverse and costovertebral joints and help to differentiate the cause of the abnormal motion noted on the habitual movement tests. By correlating the findings from these tests, the therapist can determine if the abnormal movement pattern is due to a hypomobile joint or an outside influence (myofascial, neural). Further tests are required to detect a hypermobile or unstable joint.

Active mobility tests of osteokinematic function

Forward bending (Figs. 74, 75, 76, 77, 78, 79). The following test is used to determine the osteokinematic function of two adjacent thoracic vertebrae during forward bending of the head/trunk. The transverse processes of two adjacent vertebrae are palpated with the index finger and thumb of both hands. The patient is instructed to forward bend the head/trunk and the quantity of motion as well as the symmetry of motion is noted during flexion of the thoracic segment. Both index fingers should travel superiorly an equal distance. When interpreting the mobility findings, the position of the joint at the beginning of the test should be correlated with the subsequent mobility noted, since alterations in joint mobility may merely be a reflection of an altered starting position. To determine the position of the superior vertebra, the dorsoventral relationship of the transverse processes to the coronal body plane is noted and compared with the level above and below. If the left transverse process of the superior vertebra is more dorsal than the left transverse process of the inferior vertebra then the segment is left rotat-

Figure 77.
Active mobility tests of osteokinematic function - palpation for flexion of T5-6.

ed. If the left transverse process of the superior vertebra is less dorsal than the left transverse process of the inferior vertebra but more dorsal than the right transverse process of the superior vertebra, then the superior vertebra is relatively right rotated compared to the level below but left rotated when compared to the coronal body plane. This is a typical compensatory pattern seen when a superior segment is derotating or unwinding a primary rotation at a lower level.

The following test is used to determine the osteokinematic function of a rib relative to the vertebra of the same number during for-

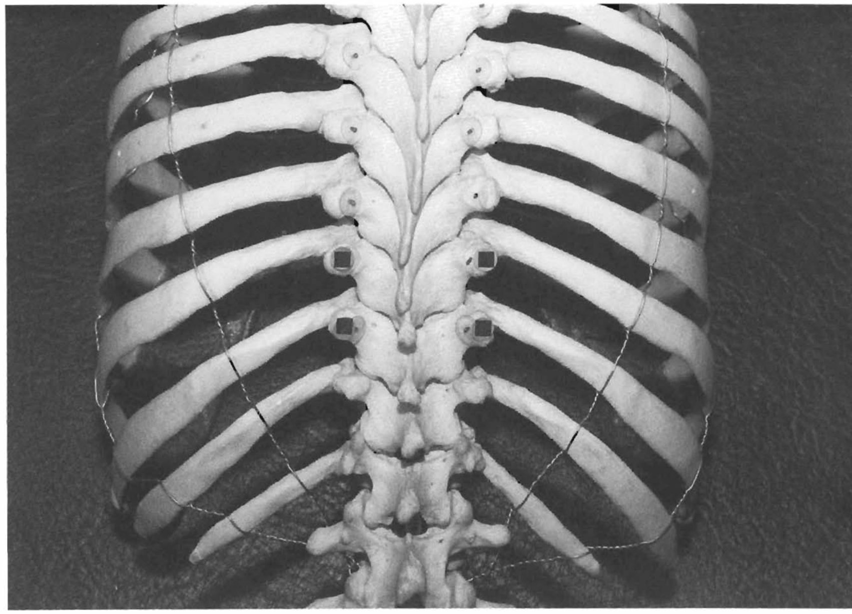


Figure 78.
Active mobility tests of osteokinematic function - points of palpation for T9-10.

Figure 79.
Active mobility tests of osteokinematic function - palpation for flexion of T9-10.

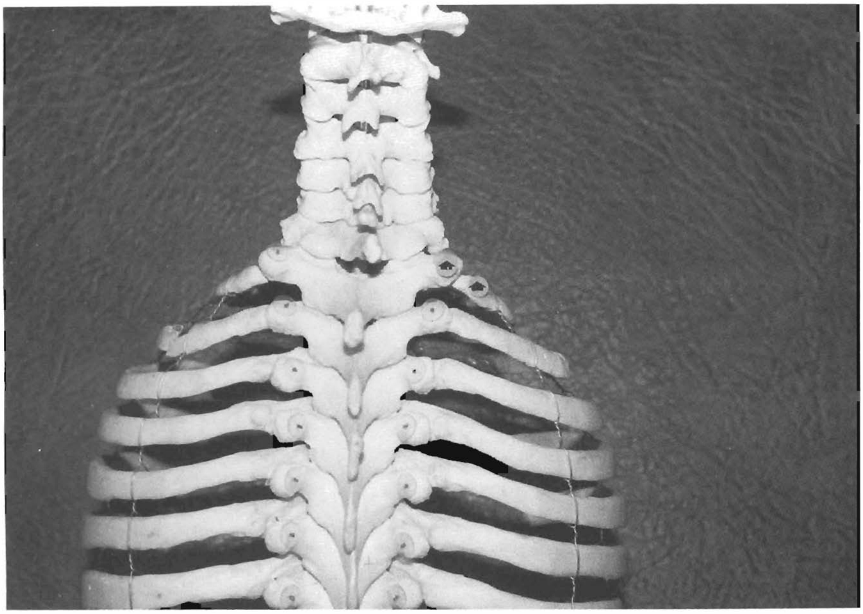


Figure 80.

Active mobility tests of osteokinematic function - points of palpation for T1 - first rib.

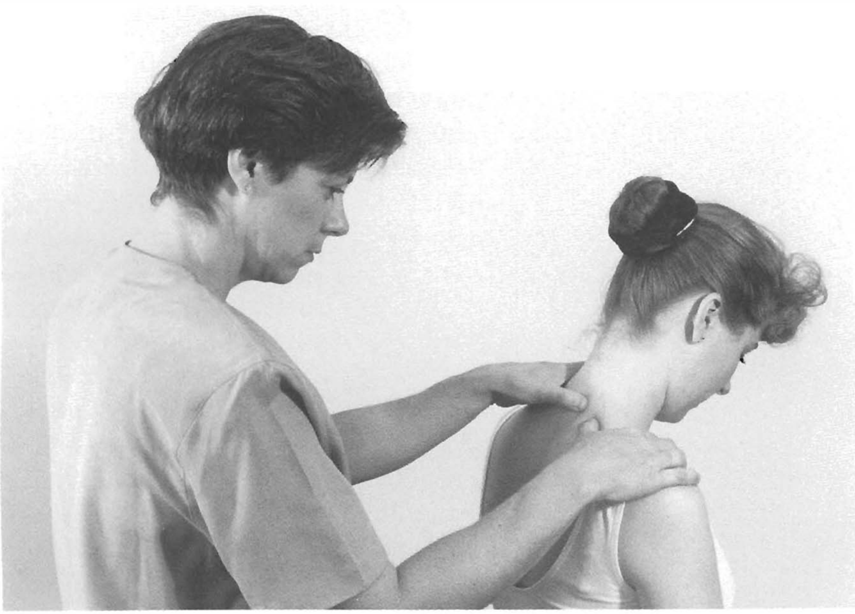


Figure 81.

Active mobility tests of osteokinematic function - palpation for flexion of the first costotransverse joint.

ward bending of the head/trunk (Figs. 80, 81, 82, 83). The transverse process is palpated with the thumb of one hand. The rib is palpated just lateral to the tubercle and medial to the angle with the thumb of the other hand. The index finger of this hand rests along the shaft of the rib. The patient is instructed to forward bend the head/trunk and the relative motion between the transverse process and the rib is noted.

In the mobile thorax, the rib should anteriorly rotate and the tuber-

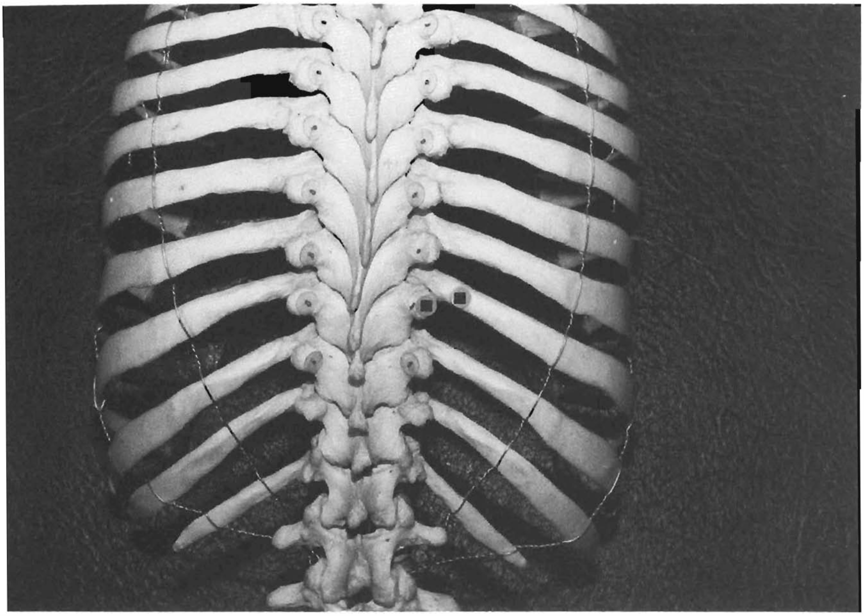


Figure 82.
Active mobility tests of osteokinematic function - points of palpation for T9 - ninth rib.

Figure 83.
Active mobility tests of osteokinematic function - palpation for flexion of the ninth costotransverse joint.

cle of the rib travel further superiorly than the transverse process. In the stiffer thorax, the rib should anteriorly rotate and the tubercle of the rib stop before full thoracic flexion is achieved such that the transverse process travels further superiorly than the rib When the relative mobility between the thoracic vertebra and the rib is the same, no motion is palpated between the vertebra and the rib during forward bending. To determine the patient's normal movement pattern it is critical to evaluate levels above, below and contralateral to the tested segment.

Figure 84.

Active mobility tests of osteokinematic function - palpation for extension of T9-10.

Figure 85.

Active mobility tests of osteokinematic function - palpation for extension of T1-2.

Backward bending. The following test is used to determine the osteokinematic function of two adjacent thoracic vertebrae during backward bending of the head/trunk. The transverse processes of two adjacent vertebrae are palpated with the index finger and thumb of both hands (Figs. 74, 76, 78). The patient is instructed to backward bend the trunk and the quantity of motion as well as the symmetry of motion is noted during extension of the thoracic segment (Fig. 84). Backward bending of the upper thorax is achieved by asking the patient to elevate both arms (Fig. 85). Both index fingers should travel inferiorly an equal distance. When interpreting the mobility findings, the position of the joint at the beginning of the test should be correlated with the subsequent mobility noted, since alterations in joint mobility may merely be a reflection of an altered starting position.

The following test is used to determine the osteokinematic function of a rib and the vertebra of the same number during backward bending of the head/trunk. The transverse process is palpated with the thumb of one hand. The rib is palpated just lateral to the tubercle and medial to the angle with the thumb of the other hand (Figs. 80, 82). The index finger of this hand rests along the shaft of the rib. The patient is instructed to backward bend the trunk and the relative motion between the transverse process and the rib is noted (Fig. 86). Backward bending of the upper thorax is achieved by asking the patient to elevate both arms (Fig. 87).

Figure 86.
Active mobility tests of osteokinematic function - palpation for extension of the ninth costotransverse joint.

Figure 87.
Active mobility tests of osteokinematic function - palpation for extension of the first costotransverse joint.

In the mobile thorax, the rib should posteriorly rotate and the tubercle of the rib travel further inferiorly than the transverse process. In the stiffer thorax, the rib should posteriorly rotate and the tubercle of the rib stop before full thoracic extension is achieved such that the transverse process travels further inferiorly than the rib. When the relative mobility between the thoracic vertebra and the rib is the same, no motion is palpated between the vertebra and the rib during backward bending. To determine the patient's normal movement pattern it is critical to evaluate levels above, below and contralateral to the tested segment. In the upper thorax, the stiff pattern is normal both in the mobile and stiff thorax.

Lateral bending. The following test is used to determine the osteokinematic function of two adjacent thoracic vertebrae during lateral bending of the head/trunk. The transverse processes of two adjacent vertebrae are palpated with the index finger and thumb of both hands (Figs. 74, 76, 78). The patient is instructed to lateral bend the head/trunk and the quantity and direction of motion is noted. In the upper thorax, the superior thoracic vertebra should lateral bend and rotate to the same side such that the superior transverse process on the side of the concavity moves dorsally and inferiorly (Fig. 88). Below T3, the superior thoracic vertebra should lateral bend in the pure coronal plane until the last few degrees of movement. At this point, the superior vertebra should rotate contralateral to the direction of the lateral bend. The superior trans-

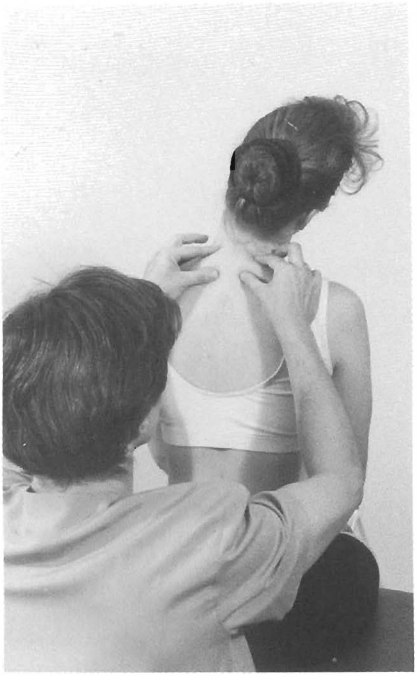


Figure 88.
Active mobility tests of osteokinematic function - palpation for right lateral bending of T1-2.

Figure 89.
Active mobility tests of osteokinematic function - palpation for right lateral bending of the fifth costotransverse joint.

verse process on the side of the concavity should move inferiorly and ventrally.

Below T7, the direction of motion coupling depends on the apex of the curve (Chapter 2). The direction of rotation should be congruent with the levels above and below.

The following test is used to determine the osteokinematic function of a rib and the vertebra of the same number during lateral bending of the head/trunk. The transverse process is palpated with the thumb of one hand. The rib is palpated just lateral to the tubercle and medial to the angle with the thumb of the other hand (Figs. 80, 82). The index finger of this hand rests along the shaft of the rib. The patient is instructed to lateral bend the head/trunk and the relative motion between the transverse process and the rib is noted (Fig. 89).

Rotation. The following test is used to determine the osteokinematic function of two adjacent thoracic vertebrae during rotation of the head/trunk. The transverse processes of two adjacent vertebrae are palpated with the index finger and thumb of both hands (Figs. 74, 76, 78). The patient is instructed to rotate the head/trunk and the quantity and direction of motion is noted. In the upper thorax (vertebromanubrial) and the vertebrosternal regions, the superior thoracic vertebra should lateral bend and rotate to the same side such that the superior transverse process on the side of the

Figure 90.
Active mobility tests of osteokinematic function - palpation for right rotation of T5-6.

Figure 91.
Active mobility tests of osteokinematic function - palpation for right rotation of the fifth costotransverse joint.

concavity moves dorsally and inferiorly (Fig. 90). Below T7, the direction of the conjunct lateral bend is variable. It may be either to the same side as the rotation or to the opposite side.

The following test is used to determine the osteokinematic function of a rib and the vertebra of the same number during rotation of the head/trunk. The transverse process is palpated with the thumb of one hand. The rib is palpated just lateral to the tubercle and medial to the angle with the thumb of the other hand (Figs. 80, 82). The index finger of this hand rests along the shaft of the rib. The patient is instructed to rotate the head/trunk and the relative motion between the transverse process and the rib is noted (Fig. 91).

Respiration. The following test is used to determine the osteokinematic function of a rib relative to the vertebra of the same number during respiration. The transverse process is palpated with the thumb of one hand. The rib is palpated just lateral to the tubercle and medial to the angle with the thumb of the other hand (Figs. 80, 82). The index finger of this hand rests along the shaft of the rib. The patient is instructed to breathe in fully and the relative motion between the transverse process and the rib is noted. The patient is then instructed to breathe out fully and the relative motion between the transverse process and the rib is noted (Fig. 92).

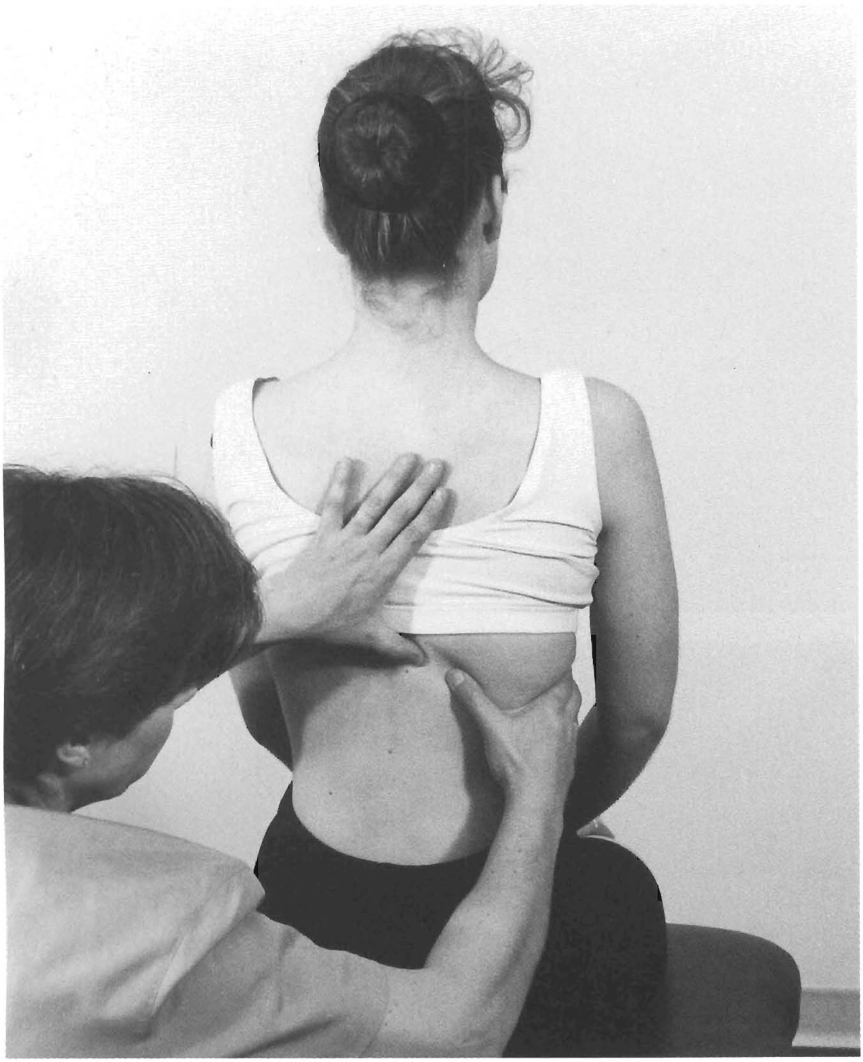


Figure 92.
Active mobility tests of osteokinematic function - palpation for respiration of the ninth costotransverse joint.

Passive physiological mobility tests

Passive physiological mobility tests are used to confirm the level of the abnormal movement pattern noted on active mobility testing. In addition, the quality of the end feel of motion is determined during these tests.

With the patient sitting and the arms crossed to the opposite shoulders for the vertebromanubrial and vertebrosternal regions, the transverse processes of the superior vertebra are palpated. In the thoracolumbar region, the interspinous space is palpated. The head/trunk is passively flexed, extended, laterally flexed and rotated. The quantity of motion and the quality of the end feel is noted and compared to the levels above and below.

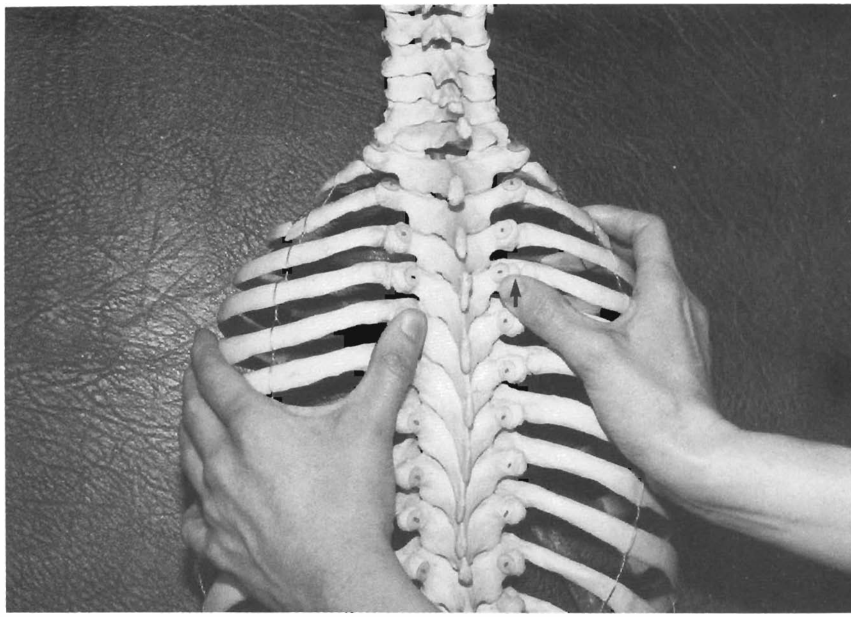


Figure 93.
Passive mobility tests of arthrokinematic function - points of palpation for superior glide of the right T4-5 zygapophyseal joint.

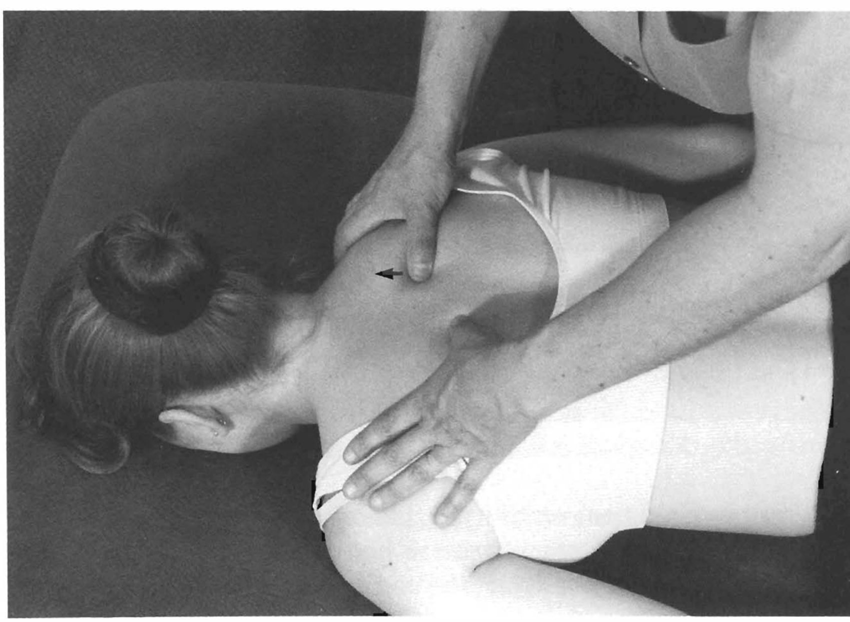


Figure 94.
Passive mobility tests of arthrokinematic function - superior glide of the right T4-5 zygapophyseal joint.

Passive mobility tests of arthrokinematic function

Zygapophyseal joints - Eg. T4-5 to test the superior glide of the right zygapophyseal joint (Figs. 93, 94). This test is used to determine the ability of the right inferior articular process of T4 to glide superiorly relative to the superior articular process of T5. With the patient prone and the thoracic spine in neutral, the inferior aspect of the left transverse process of T5 is palpated with the left thumb. The right thumb palpates the inferior aspect of the right transverse

Figure 95.

Passive mobility tests of arthrokinematic function - points of palpation for inferior glide of the right T4-5 zygapophyseal joint.

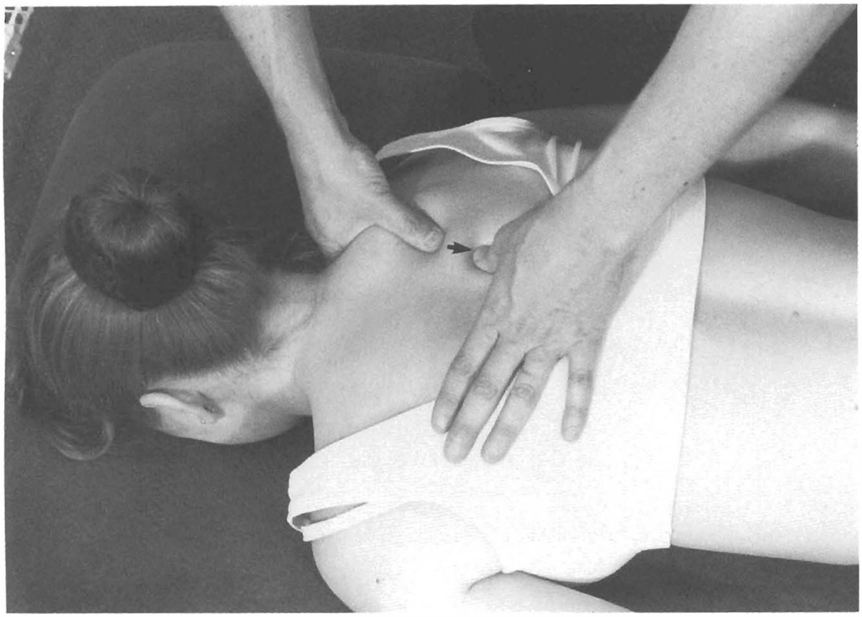


Figure 96.

Passive mobility tests of arthrokinematic function - inferior glide of the right T4-5 zygapophyseal joint.

process of T4. The left thumb fixes T5 and a superoanterior glide is applied to T4 with the right thumb. The quantity and end feel of motion is noted and compared to the levels above and below. This technique can be used for all thoracic segments.

Zygapophyseal joints - Eg. T4-5 to test the inferior glide of the right zygapophyseal joint (Figs. 95, 96). This test is used to determine the ability of the right inferior articular process of T4 to glide inferiorly relative to the superior articular process of T5. With the

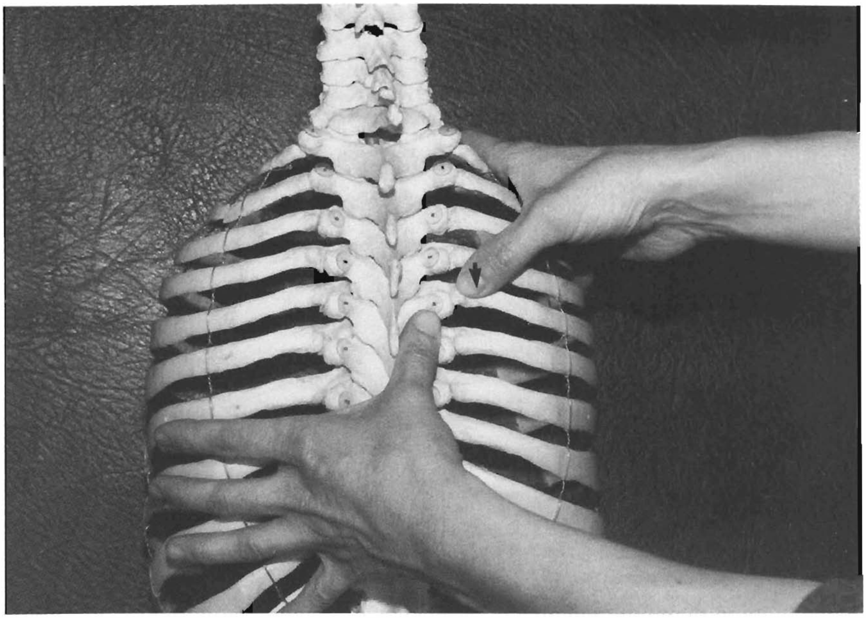


Figure 97.
Passive mobility tests of arthrokinematic function - points of palpation for inferior glide of the right fifth costotransverse joint.

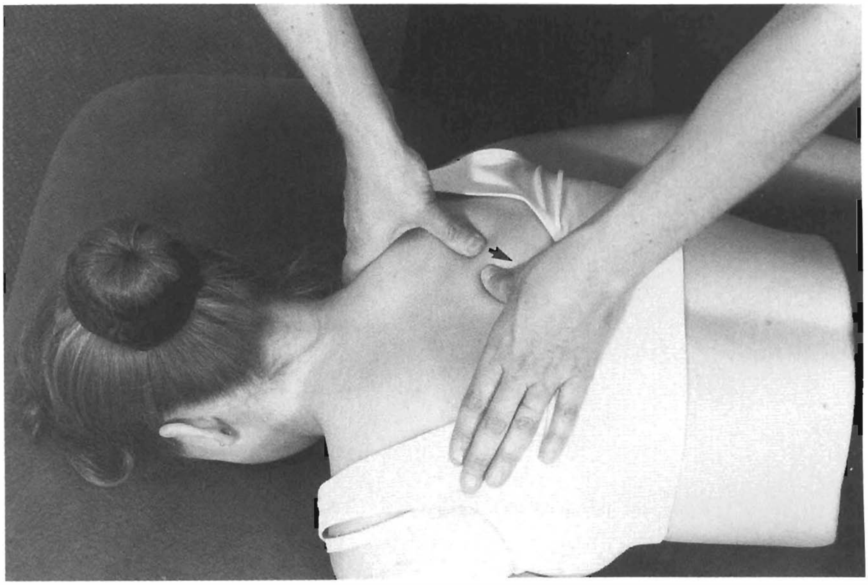


Figure 98.
Passive mobility tests of arthrokinematic function - inferior glide of the right fifth costotransverse joint.

patient prone and the thoracic spine in neutral, the inferior aspect of the transverse process of T5 is palpated with the left thumb. The right thumb palpates the superior aspect of the right transverse process of T4. The left thumb fixes T5 and an inferior glide is applied to T4 with the right thumb. The quantity and end feel of motion is noted and compared to the levels above and below. This technique can be used for all thoracic segments.

Costotransverse joints - Eg. To test the inferior glide of the right fifth rib at the costotransverse joint (Figs. 97, 98). This test is used

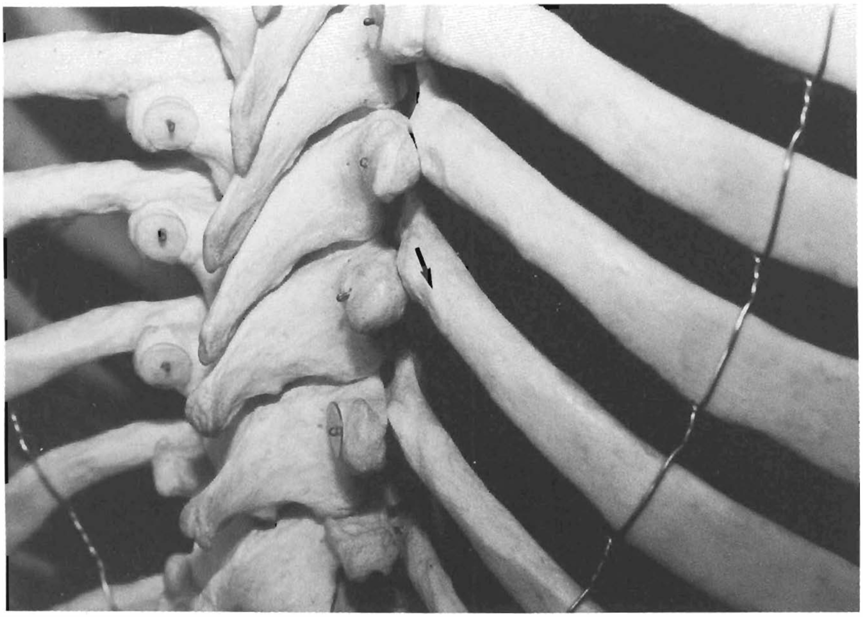


Figure 99.
Passive mobility tests of arthrokinematic function - The direction of the costotransverse joint glide is anterolateroinferior at the level of the ninth rib (arrow).

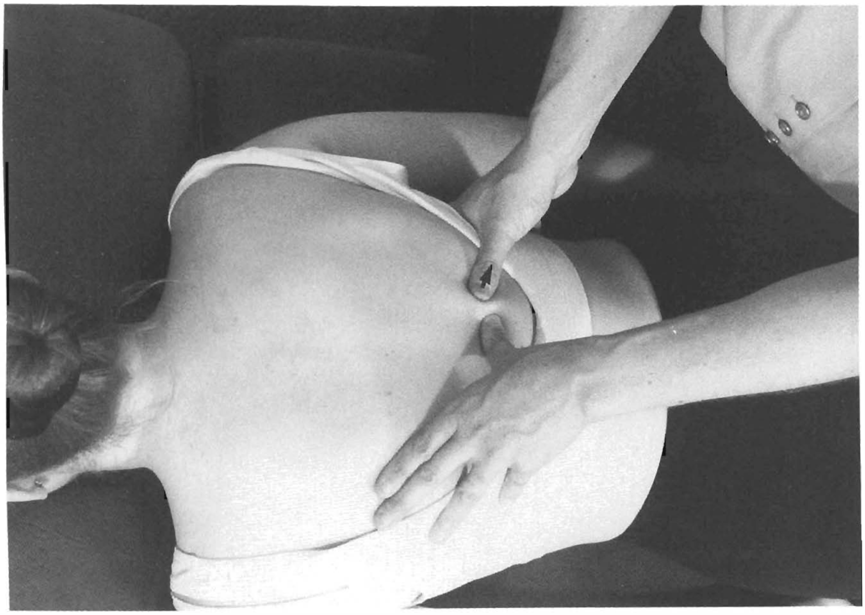


Figure 100.
Passive mobility tests of arthrokinematic function - inferior glide of the right ninth costotransverse joint.

to determine the ability of the right fifth rib to glide inferiorly relative to the transverse process of T5. With the patient prone and the thoracic spine in neutral, the inferior aspect of the right transverse process of T5 is palpated with the left thumb. The right thumb palpates the superior aspect of the right fifth rib just lateral to the tubercle. The left thumb fixes T5 and an inferior glide (allowing the conjunct posterior roll to occur) is applied to the fifth rib with the right thumb. The quantity and end feel of motion is noted and compared to the levels above and below.

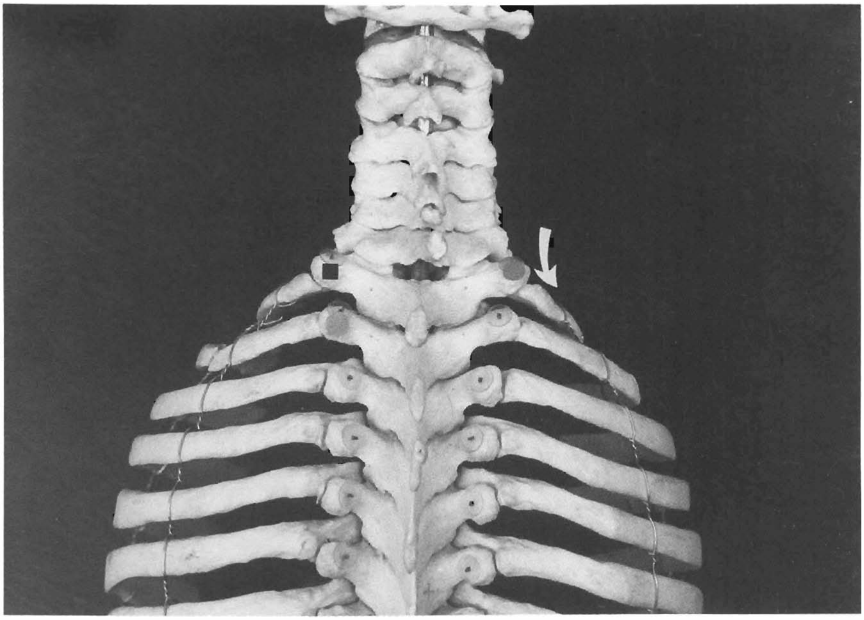


Figure 101.
Passive mobility tests of arthrokinematic function - points of palpation (black box and white arrow) for inferior glide of the right first costotransverse joint.

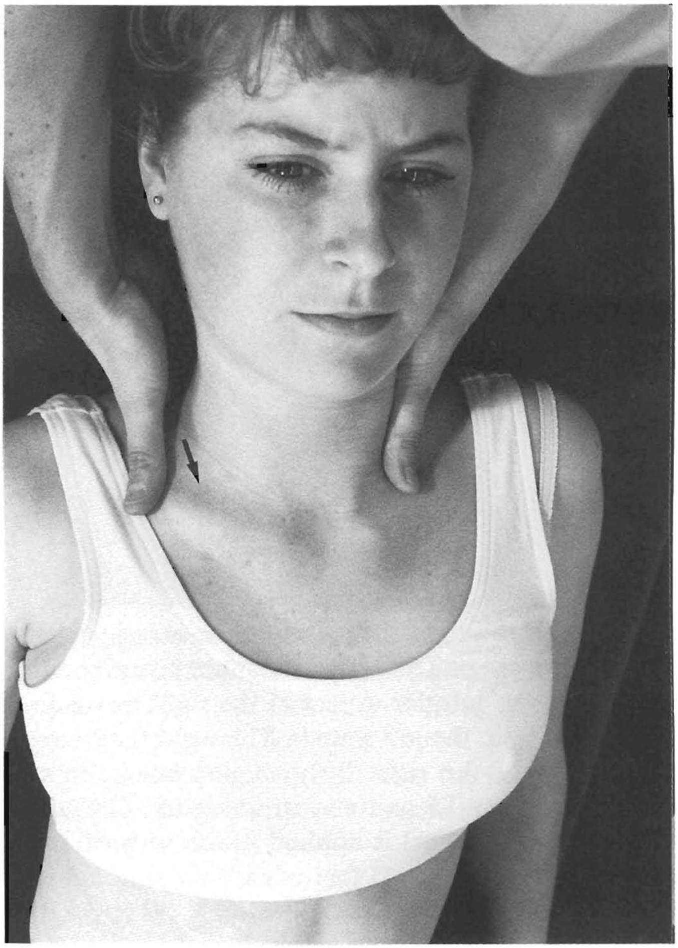


Figure 102.
Passive mobility tests of arthrokinematic function - inferior glide of the right first costotransverse joint.

Figure 103.
Passive mobility tests of arthrokinematic function - points of palpation for superior glide of the right fifth costotransverse joint.

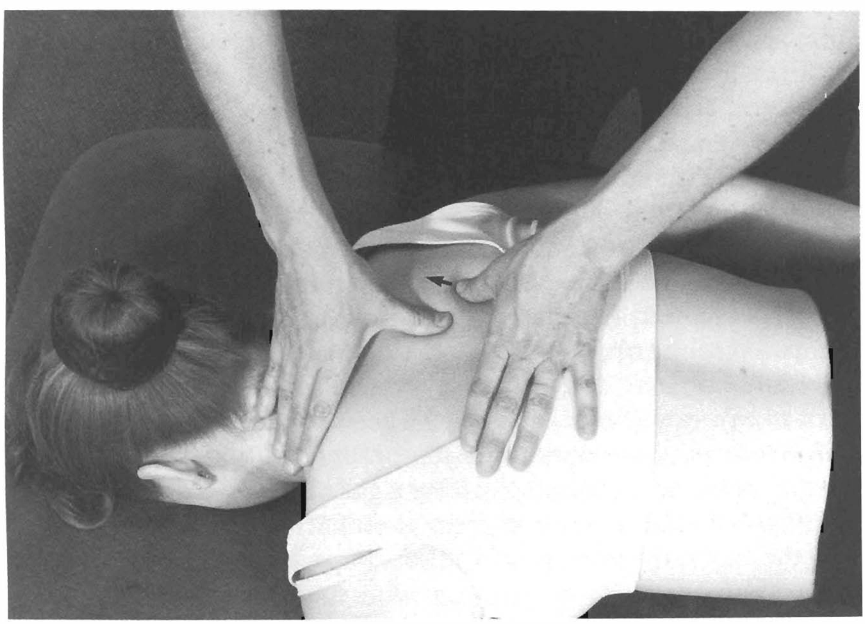


Figure 104.
Passive mobility tests of arthrokinematic function - superior glide of the right fifth costotransverse joint.

Between T7 and T10 the orientation of the costotransverse joint changes such that the direction of the glide is anterolateroinferior. The position of the right hand is modified to facilitate this change in joint direction such that the index finger of the right hand lies along the shaft of the rib and assists in gliding the rib in an anterolateroinferior direction (Figs. 99, 100).

Costotransverse joints - Eg. To test the inferior glide of the right first rib at the costotransverse joint (Figs. 101, 102). This test is

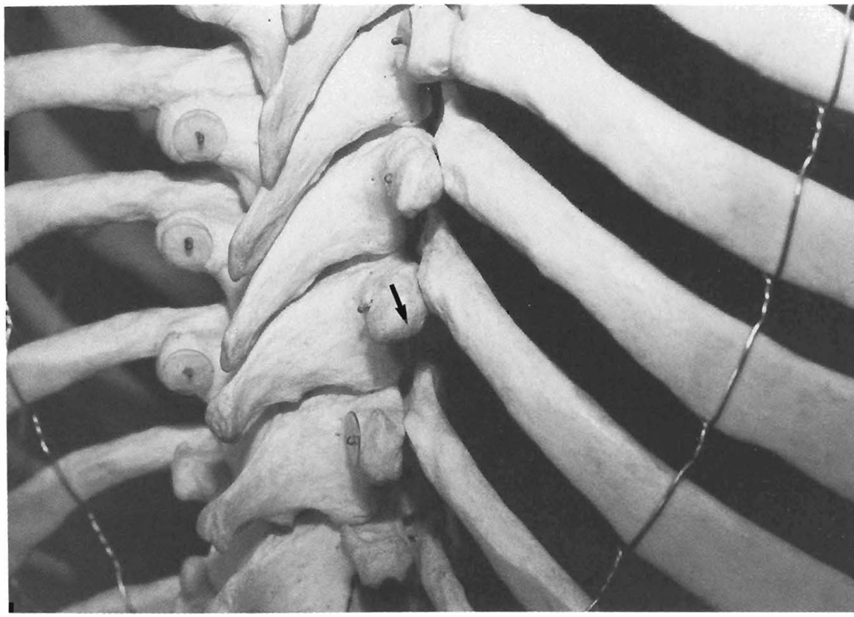


Figure 105.
Passive mobility tests of arthrokinematic function - The direction of the costotransverse joint glide is posteromediosuperior at the level of the ninth rib and is achieved by gliding the transverse process of T9 anterolateroinferior (arrow).

used to determine the ability of the right first rib to glide inferiorly relative to the transverse process of T1. The patient lies supine with the head and neck comfortably supported on a pillow. With the lateral aspect of the MCP of the index finger of the left hand, the superior aspect of the left transverse process of T1 is palpated and fixed. With the lateral aspect of the MCP of the index finger of the right hand, the superior aspect of the right first rib is palpated just lateral to the costotransverse joint. The left hand fixes T1 and an inferoanterior glide (allowing the conjunct posterior rotation to occur) is applied. The quantity and end feel of motion is noted and compared to the opposite side.

Costotransverse joints - Eg. To test the superior glide of the right fifth rib at the costotransverse joint (Figs. 103, 104). This test is used to determine the ability of the right fifth rib to glide superiorly relative to the transverse process of T5. With the patient prone and the thoracic spine in neutral, the superior aspect of the transverse process of T5 is palpated with the right thumb. The left thumb palpates the inferior aspect of the right fifth rib just lateral to the tubercle. The right thumb fixes T5 and a superior glide (allowing the conjunct anterior roll to occur) is applied to the fifth rib with the left thumb. The quantity and end feel of motion is noted and compared to the levels above and below.

Between T7 and T10 the orientation of the costotransverse joint changes such that the glide is posteromediosuperior. The position of the right hand is modified to facilitate this change in joint direction such that the index finger of the right hand lies along the shaft

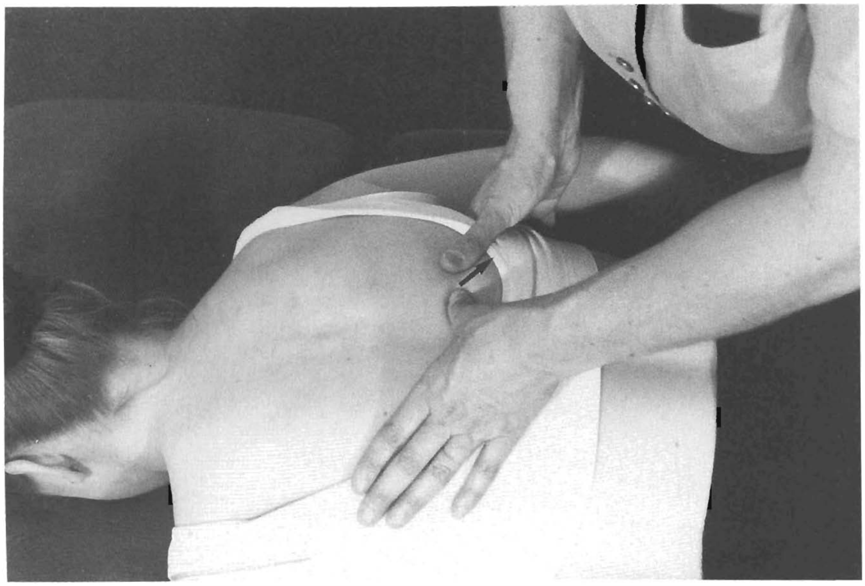


Figure 106.
Passive mobility tests of arthrokinematic function - posteromediosuperior glide of the right ninth costotransverse joint.

of the rib. The right hand fixes the rib and the transverse process is glided anterolateroinferior thus producing a relative posteromediosuperior glide of the rib at the costotransverse joint (Figs. 105, 106).

Costotransverse joints - Eg. To test the superior glide of the right first rib at the costotransverse joint (Figs. 107, 108). This test is used to determine the ability of the right first rib to glide superiorly relative to the transverse process of T1. The patient lies supine with the head and neck comfortably supported on a pillow. The superior aspect of the right transverse process of T1 is palpated with the right thumb. The index and middle fingers of the right hand palpate the inferior aspect of the right first rib. The right index and middle fingers fix the first rib and a posteroinferior glide (allowing the conjunct anterior rotation to occur) is applied to the transverse process of T1 thus producing a relative superior glide of the first rib at the costotransverse joint. The quantity and end feel of motion is noted and compared to the opposite side.

Mediolateral translation - Eg. To test the ability of T5 and the right and left sixth ribs to glide transversely to the right on the T6 vertebra (Figs. 109, 110). This motion is necessary for full left rotation/left sideflexion to occur. It requires the left sixth rib to glide anteromedially relative to the left transverse process of T6 and the right sixth rib to glide posterolaterally relative to the right transverse process of T6. The patient is sitting with the arms crossed to opposite shoulders. With the right hand/arm, palpate the thorax such that the fifth finger of the right hand lies along the sixth rib. With the left hand, fix the transverse processes of T6. With the

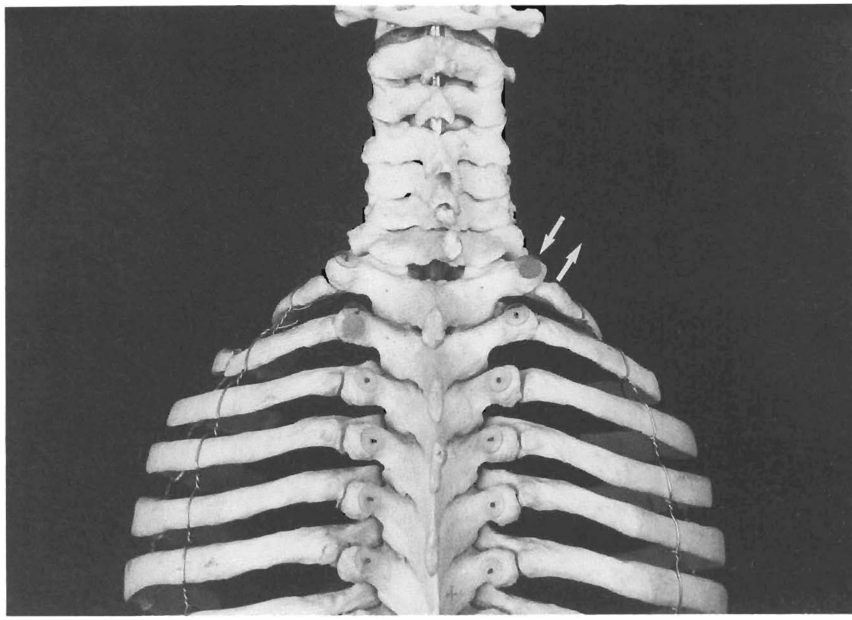


Figure 107.
Passive mobility tests of arthrokinematic function - points of palpation (two white arrows) for superior glide of the right first costotransverse joint.

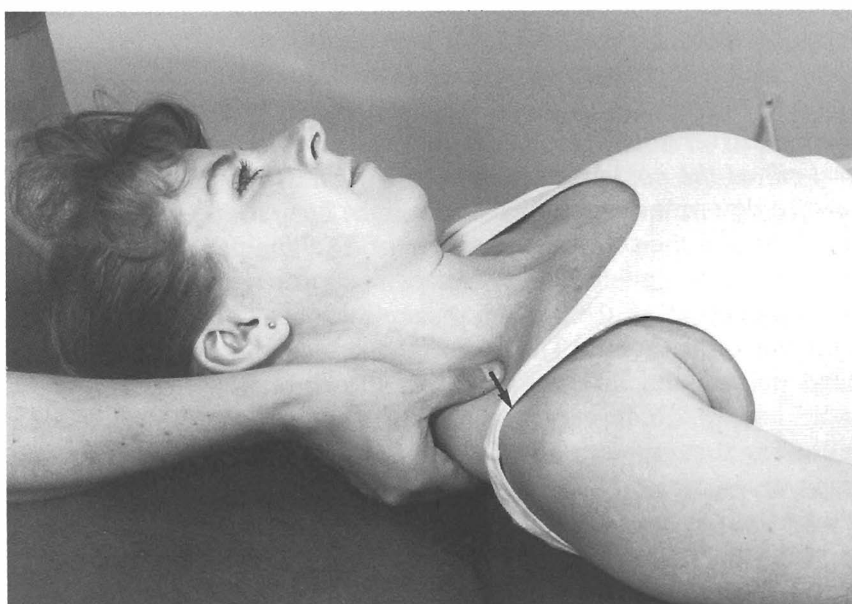


Figure 108.
Passive mobility tests of arthrokinematic function - superior glide of the right first costotransverse joint.

right hand/arm translate the T5 vertebra and the ribs PURELY to the right in the transverse plane. The quantity and in particular the endfeel of motion is noted and compared to the levels above and below.

Passive stability tests of arthrokinetic function[21]

Vertical (traction/compression). This test stresses the anatomical structures which resist vertical forces. A positive response is the

Figure 109.
Passive mobility tests of arthrokinematic function - points of palpation for right mediolateral translation glide of T5 and the sixth ribs.

Figure 110.
Passive mobility tests of arthrokinematic function - right mediolateral translation test of T5 and the sixth ribs.

reproduction of the patient's pain as opposed to a sense of increased osteoarticular motion. The patient is sitting with the arms crossed to opposite shoulders such that the arm closest to the chest grasps the scapula. The other arm rests on top of the contralateral shoulder. The thoracic spine is in neutral. Traction is applied to the middle and lower thorax by applying a vertical force through the patient's crossed arms (Fig. 111). Traction is applied to the upper thorax by applying a vertical force through the cranium.

Figure 111.

Passive stability tests of arthrokinetic function - traction of the middle and lower thorax.

Figure 112.

Passive stability tests of arthrokinetic function - compression of the middle and lower thorax.

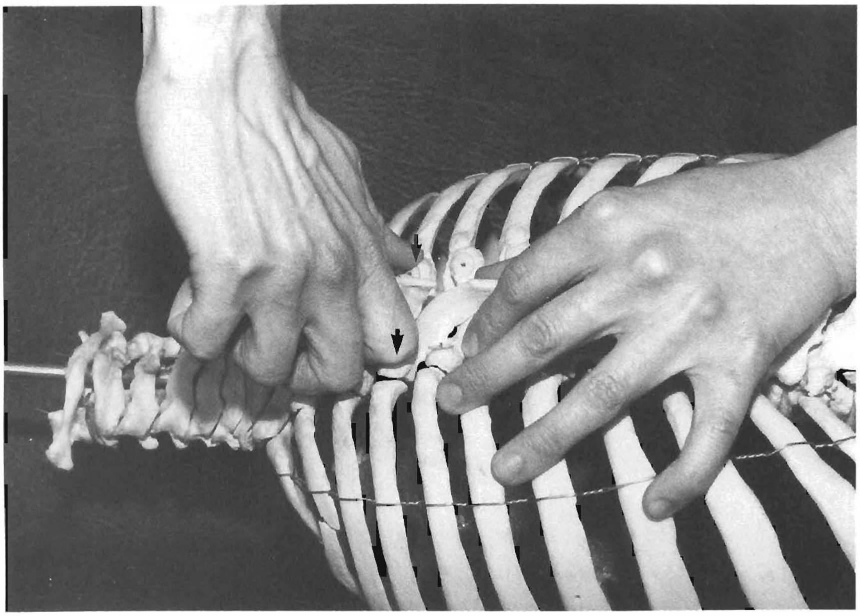


Figure 113.
Passive stability tests of arthrokinetic function - points of palpation for anterior translation (spinal).

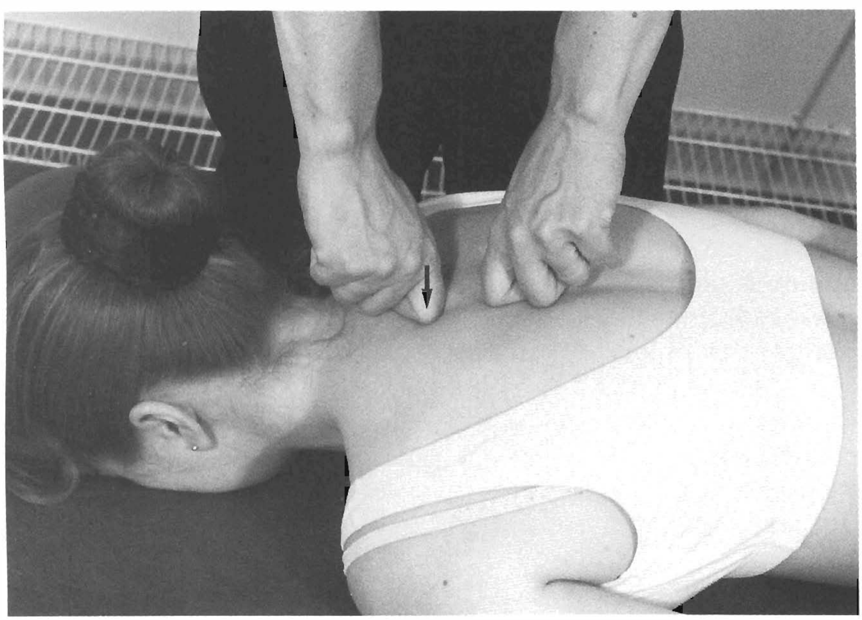


Figure 114.
Passive stability tests of arthrokinetic function - anterior translation (spinal).

Compression is applied to the middle and lower thorax by applying a vertical force through the top of the patient's shoulders (Fig. 112). Compression is applied to the upper thorax by applying a vertical force through the cranium.

Anterior translation - spinal. This test stresses the anatomical structures which resist anterior translation of a segmental spinal unit. A positive response is the reproduction of the patient's symptoms together with an increase in the quantity of motion and a decrease in the resistance at the end of the range of motion. With the patient prone lying, the transverse processes of the superior vertebra are palpated. With the other hand, the transverse processes of the inferior vertebra are fixed (Figs. 113, 114). A posteroanterior force is applied through the superior vertebra while fixing the inferior vertebra. The quantity of motion, the reproduction of any symptoms and the endfeel of motion is noted and compared to the levels above and below. The findings from this test should be correlated with those of the posterior translation test to determine the level of the instability. Excessive anterior translation of the T4 vertebra could be due to either an anterior instability of T4-5 or a posterior instability of T3-4.

Posterior translation - spinal. This test stresses the anatomical structures which resist posterior translation of a segmental spinal unit. A positive response is the reproduction of the patient's symptoms together with an increase in the quantity of motion and a decrease in the resistance at the end of the range of motion. The patient is sitting with the arms crossed to opposite shoulders. The thorax is stabilized with one hand/arm under/over (depending on the level) the patient's crossed arms and the contralateral scapula is grasped. The transverse processes of the inferior vertebra are fixed with the dorsal hand. Static stability is tested by applying an anteroposterior force to the superior vertebra through the thorax while fixing the inferior vertebra (Figs. 115, 116). The quantity of motion, the reproduction of any symptoms and the endfeel of motion is noted and compared to the levels above and below. The findings from this test should be correlated with those of the anterior translation test to determine the level of the instability.

Dynamic stability can be tested by resisting elevation of the crossed arms. If the segmental musculature is able to control the excessive posterior translation, no posterior translation will be felt and the instability is dynamically stable.

Transverse rotation - spinal. This test stresses the anatomical structures which resist rotation of a segmental spinal unit. A positive response is the reproduction of the patient's symptoms together with an increase in the quantity of motion and a decrease in the resistance at the end of the range of motion. With the patient prone lying, the transverse process of the superior vertebra is palpated. With the other hand, the contralateral transverse process of the inferior vertebra is fixed. A transverse plane rotation force is applied through the superior vertebra by applying a unilateral posteroanterior pressure while fixing the inferior vertebra (Figs. 117, 118). The quantity of motion, the reproduction of any symptoms

Figure 115.
Passive stability tests of arthrokinetic function - points of palpation for posterior translation (spinal).

Figure 116.
Passive stability tests of arthrokinetic function - posterior translation (spinal).

and the endfeel of motion is noted and compared to the levels above and below.

Anterior translation - posterior costal. This test stresses the anatomical structures which resist anterior translation of the posterior aspect of the rib relative to the thoracic vertebrae to which it attaches. A positive response is the reproduction of the patient's

Figure 117.
Passive stability tests of arthrokinetic function - points of palpation for left rotation (spinal).

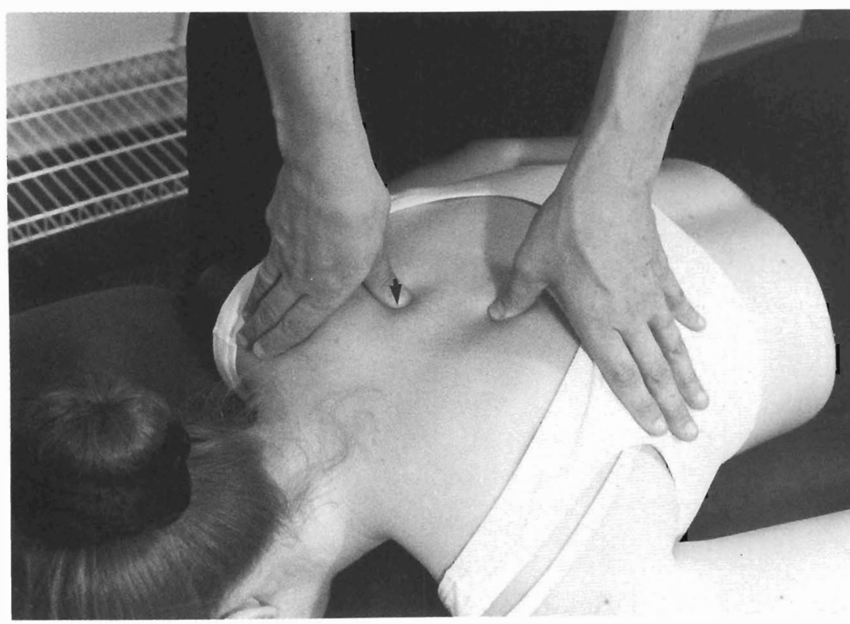


Figure 118.
Passive stability tests of arthrokinetic function - left rotation (spinal).

symptoms together with an increase in the quantity of motion and a decrease in the resistance at the end of the range of motion. With the patient prone lying, the contralateral transverse processes of the thoracic vertebrae to which the rib is attached are palpated. For example, when testing the right seventh rib the left transverse processes of T6 and T7 are palpated. With the other hand, the rib is palpated just lateral to the tubercle (Fig. 119). A posteroanterior force is applied to the rib while fixing the thoracic vertebrae (Fig. 120). The quantity of motion, the reproduction of any symptoms

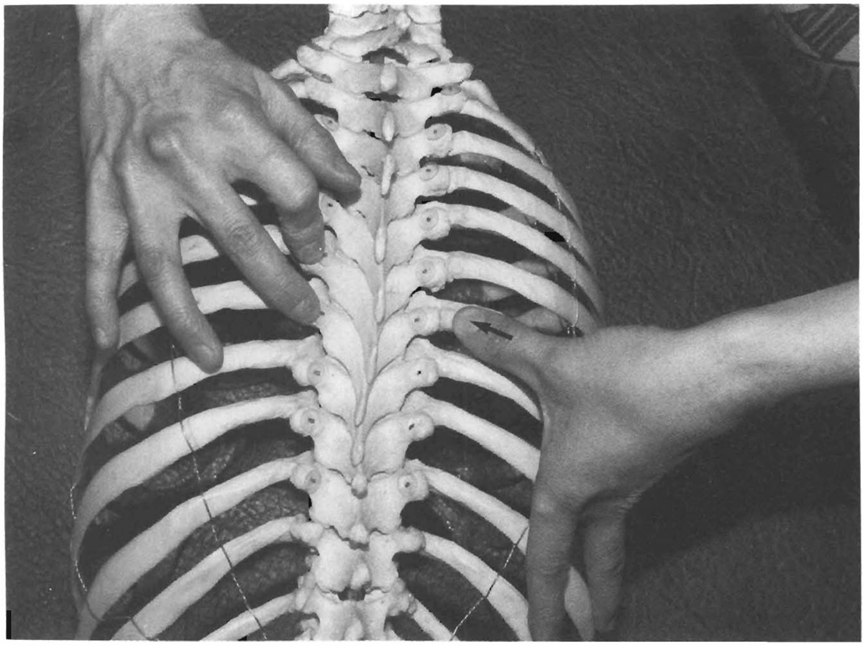


Figure 119.
Passive stability tests of arthrokinetic function - points of palpation for anterior translation (posterior costal).

Figure 120.
Passive stability tests of arthrokinetic function - anterior translation (posterior costal).

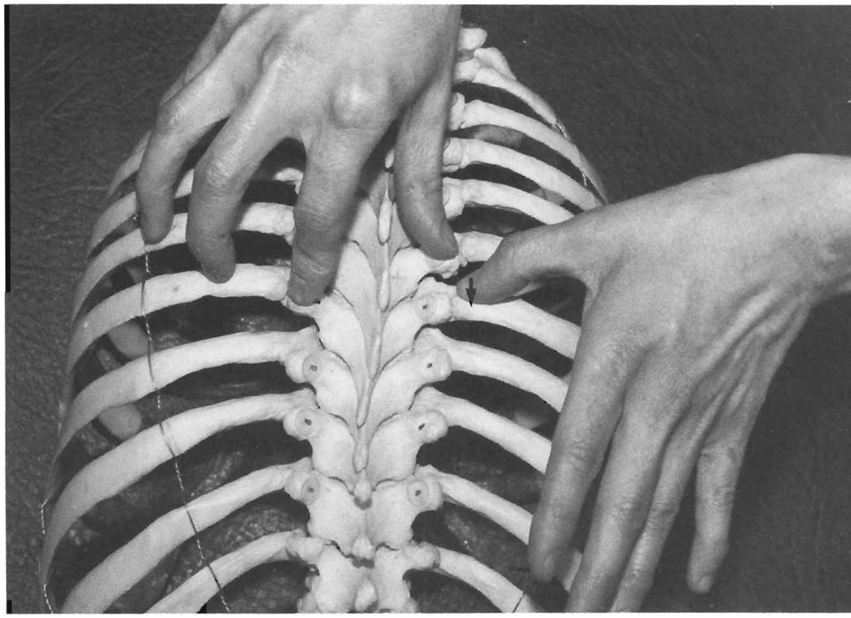


Figure 121.
Passive stability tests of arthrokinetic function - points of palpation for inferior translation (posterior costal).

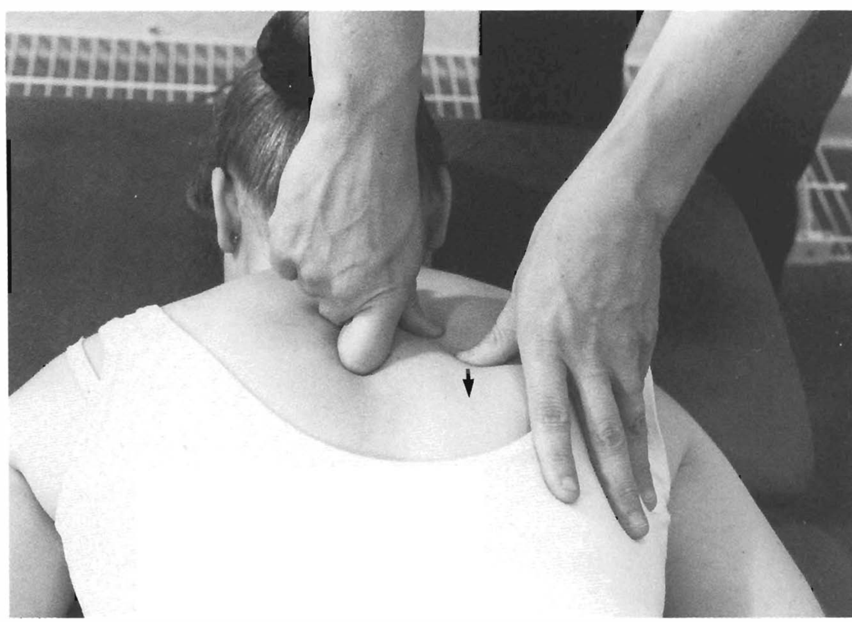


Figure 122.
Passive stability tests of arthrokinetic function - inferior translation (posterior costal).

and the endfeel of motion is noted and compared to the levels above and below.

Inferior translation - posterior costal. This test stresses the anatomical structures which resist inferior translation of the rib relative to the thoracic vertebrae to which it attaches. A positive response is the reproduction of the patient's symptoms together with an increase in the quantity of motion and a decrease in the resistance at the end of the range of motion. With the patient prone lying, the contralateral transverse process of the thoracic vertebra at the same level as the rib is palpated. With the same hand, the ipsilateral transverse process of the thoracic vertebra at the level above the rib is palpated. With the other hand, the superior aspect of the rib just lateral to the tubercle is palpated. An inferior force is applied through the rib while fixing the thoracic vertebrae (Figs. 121, 122). The quantity of motion, the reproduction of any symptoms and the endfeel of motion is noted and compared to the levels above and below.

Anterior/Posterior translation - anterior costal. This test stresses the anatomical structures which resist translation of the costocartilage relative to the sternum; and the rib relative to the costocartilage. When the sternocostal and/or costochondral joints have been separated, a gap and a step can be palpated at the joint line. The positional findings are noted prior to stressing the joint. A positive response is the reproduction of the patient's symptoms together with an increase in the quantity of motion and a decrease in the resistance at the end of the range of motion. With one thumb, the anterior aspect of the sternum/costocartilage is palpated. With the other thumb, the anterior aspect of the costocartilage/rib is palpated. A anteroposterior/posteroanterior force is applied to the costocartilage/rib (Figs. 123, 124). The quantity of motion, the reproduction of any symptoms and the endfeel of motion is noted and compared to the levels above and below.

Superior/Inferior translation - anterior costal. This test stresses the anatomical structures which resist superior/inferior translation of the costocartilage relative to the sternum; and the rib relative to the costocartilage. When the sternocostal and/or costochondral joints have been separated, a gap and a step can be palpated at the joint line. The positional findings are noted prior to stressing the joint. A positive response is the reproduction of the patient's symptoms together with an increase in the quantity of motion and a decrease in the resistance at the end of the range of motion. With one thumb, the anterior aspect of the sternum/costocartilage is palpated. With the other thumb, the inferior/superior aspect of the costocartilage/rib is palpated. A superior/inferior force is applied to the costocartilage/rib (Figs. 125, 126). The quantity of motion, the reproduction of any symptoms and the endfeel of motion is noted and compared to the levels above and below.

Mediolateral translation. This test stresses the anatomical structures which resist horizontal translation between two adjacent

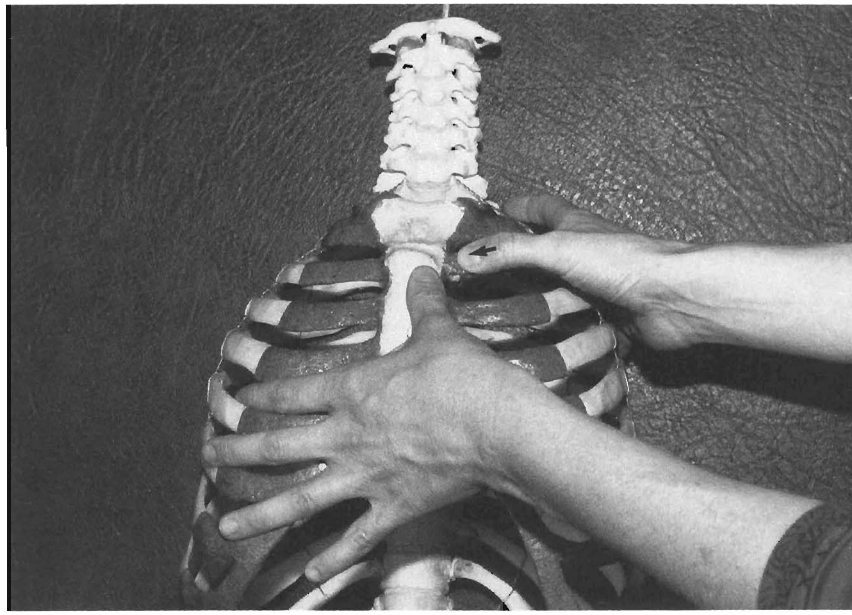


Figure 123.
Passive stability tests of arthrokinetic function - anteroposterior translation (anterior sternocostal).

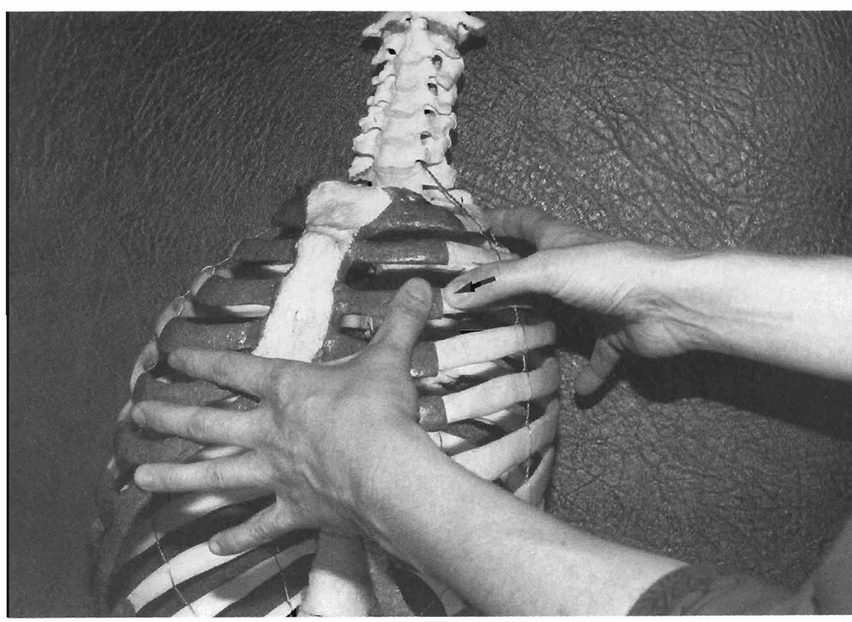


Figure 124.
Passive stability tests of arthrokinetic function - anteroposterior translation (anterior costochondral).

vertebrae when the ribs between them are fixed. This test is used between the segments T3-4 and T10-11. The primary structure being tested is the intervertebral disc. When the ribs are fixed bilaterally there should be very little, if any, mediolateral translation between two thoracic vertebrae. A positive response is an increase in the quantity of motion and a decrease in the resistance at the end of the range. To test the T5-6 segment, the patient is sitting with the arms crossed to opposite shoulders. With the right hand/arm, the thorax is palpated such that the

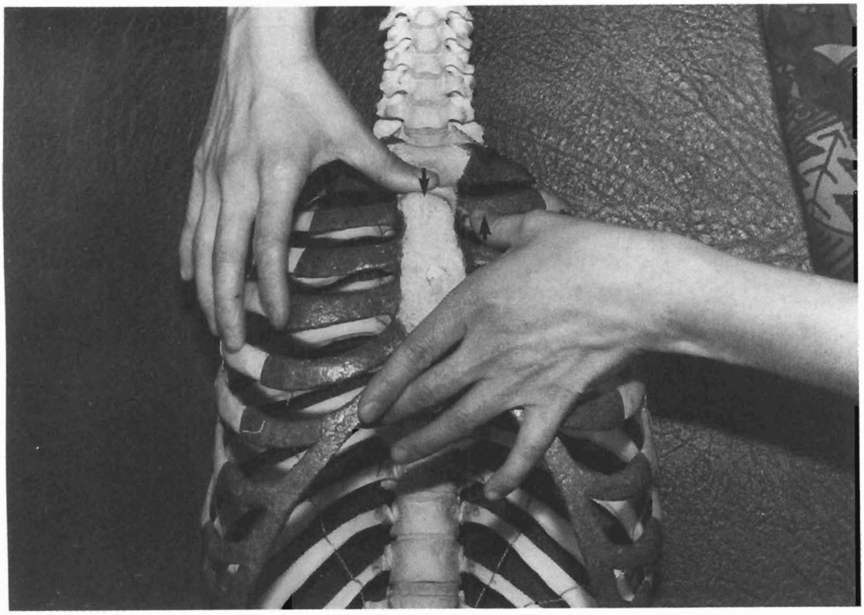


Figure 125.
Passive stability tests of arthrokinetic function - superior translation (anterior sternocostal).

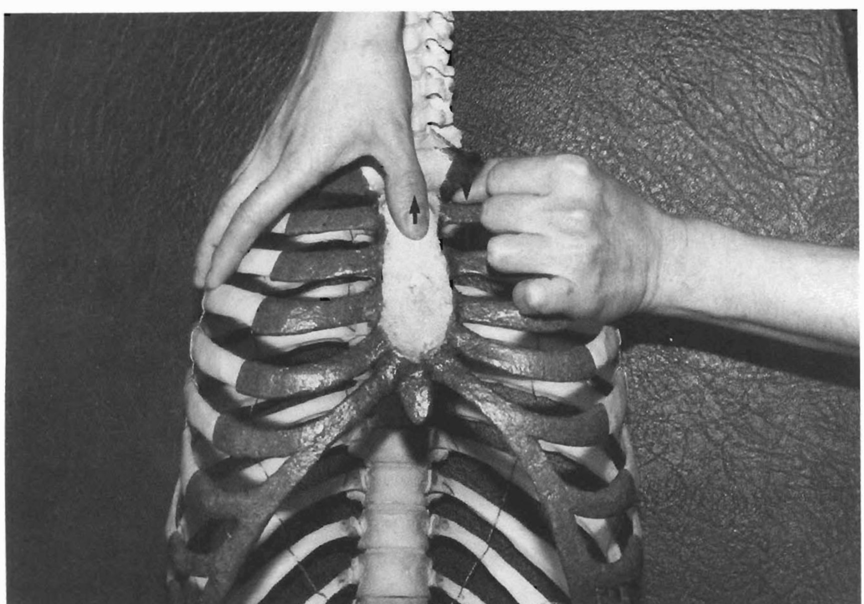


Figure 126.
Passive stability tests of arthrokinetic function - inferior translation (anterior sternocostal).

fifth finger of the right hand lies along the fifth rib. With the left hand, T6 and the sixth ribs are fixed bilaterally by compressing the ribs centrally towards their costovertebral joints (Fig. 127). The T5 vertebra is translated through the thorax PURELY in the transverse plane. The quantity of motion, the reproduction of any symptoms and the endfeel of motion is noted and compared to the levels above and below.

Figure 127.
Passive stability tests of arthrokinetic function - T5-6 mediolateral translation stability test.

Muscle function

If the specific tests of articular function are normal, then the muscles which can influence the thorax are assessed. Hypertonicity, secondary to segmental facilitation, manifests as a multisegmental dysfunction (rotoscoliosis) during the habitual movements which require lengthening of the muscle. Muscle imbalances due to faulty recruitment patterns also produce a multisegmental dysfunction. In both instances the passive mobility tests of arthrokinematic function are normal. Muscles which posture in a shortened position will eventually become structurally shorter. When the muscle is facilitated, a neurophysiological technique aimed at restoring the resting tone of the muscle will yield an immediate change in mobility. When the muscle is structurally shortened, stronger stretching techniques and more time is required to achieve normal mobility.

The diaphragm is often involved in postural dysfunction and tends to be a flexor of the thorax when it is hypertonic. It has been observed[22] to produce a lordosis at the thoracolumbar junction. In addition, insufficient relaxation of the diaphragm can lead to overuse of the midthoracic spinal extensors causing a midthoracic lordosis (Fig. 128). These curve reversals do not

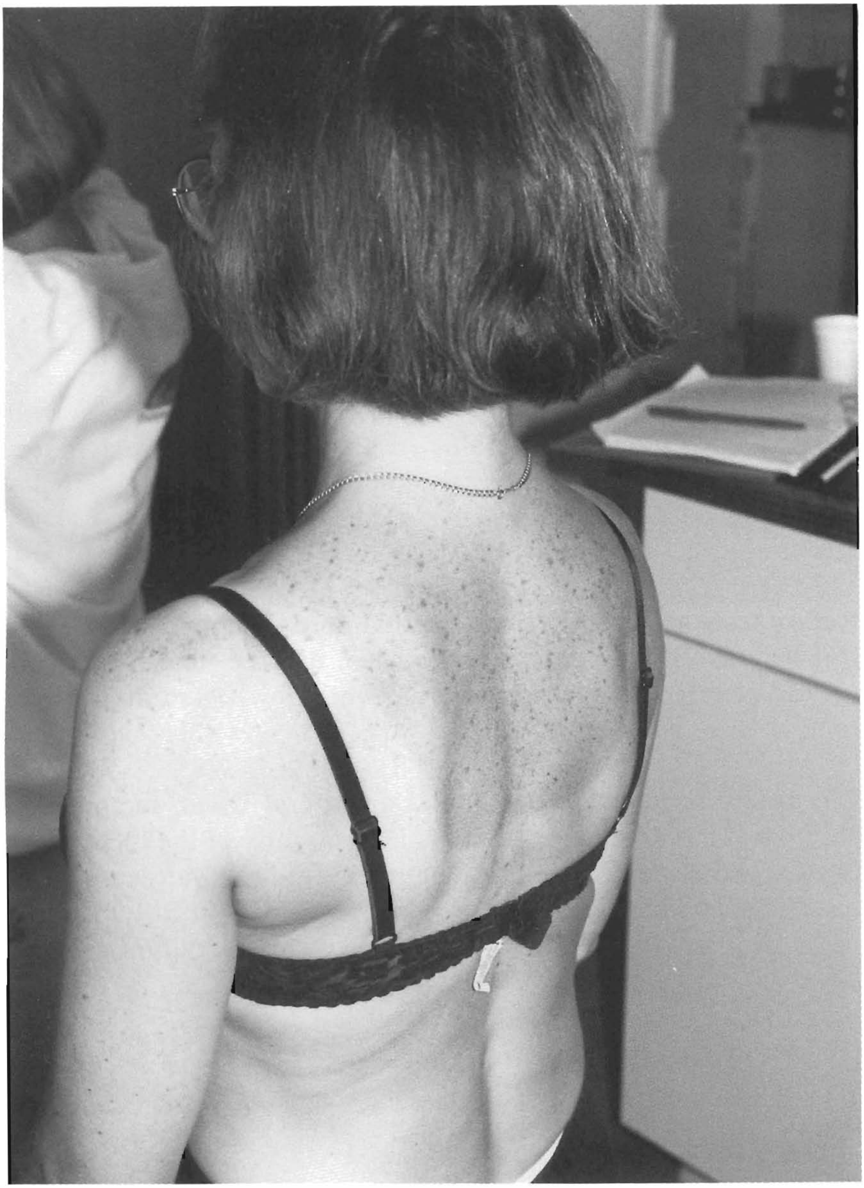


Figure 128.
When the diaphragm is hypertonic, overactivity of the midthoracic spinal extensors can produce a localized lordosis.

respond to segmental mobilization techniques. Correction requires relaxation of the diaphragm and treatment of the breathing disorder.

The emphasis of this text is on the identification and treatment of articular dysfunction and the reader is referred to other texts for elaboration on postural and muscle disorders[17].

Nerve function

These tests examine the conductivity of the motor and sensory nerves as well as the mobility of the dura and the intercostal nerves in the spinal canal and intervertebral foramen. The sensory function of the intercostal nerves is examined by testing skin sensation in the intercostal spaces. Altered sensation is not uncommon although rarely reported as a primary complaint. Hyperaesthesia can be one of the first signs of neurological interference and tends to occur long before sensation becomes reduced (hypoaesthesia).

The motor function of the intercostal nerves is examined by observing and palpating the intercostal muscles. Segmental facilitation leads to hypertonicity of the intercostal muscle and the increased tone can be palpated along the intercostal space. The tone is often associated with tender points within the muscle. Reduced motor function of the intercostal nerves causes atrophy of the intercostal muscles.

Reflex tests are used to detect spinal cord or upper motor neuron lesions. The plantar response test and the test for clonus should be done on every patient presenting with pain in the thorax.

The mobility tests for the neural and dural tissue include the slump test and variations thereof. The mobility of the intraspinal tissues can be tested by fully lengthening the dural/neural system. This is achieved by having the seated patient fully flex the head and neck, slump the thoracolumbar spine and extend the knee with the ankle dorsiflexed (Fig. 129). The dura is released by then having the patient extend the head and neck. The change in symptom response is noted. If the thoracic pain is brought on by full slump and relieved with extension of the head and neck, involvement of the dura is suggested[23].

The intercostal nerves can be further tensed by having the 'slumped' patient twist the thorax to the left and right (Fig. 130). Often, the patient will present with a normal movement pattern when rotation occurs in a position of relative neural relaxation and an abnormal movement pattern (segmental kink in the thoracic curve) when the rotation occurs in a position of relative neural tension. It is interesting to postulate on the etiology of the 'apparent segmental dysfunction' in this situation and unless the nervous system is addressed, the symptoms persist regardless of the articular and myofascial treatments employed. The emphasis of this text is on the assessment and

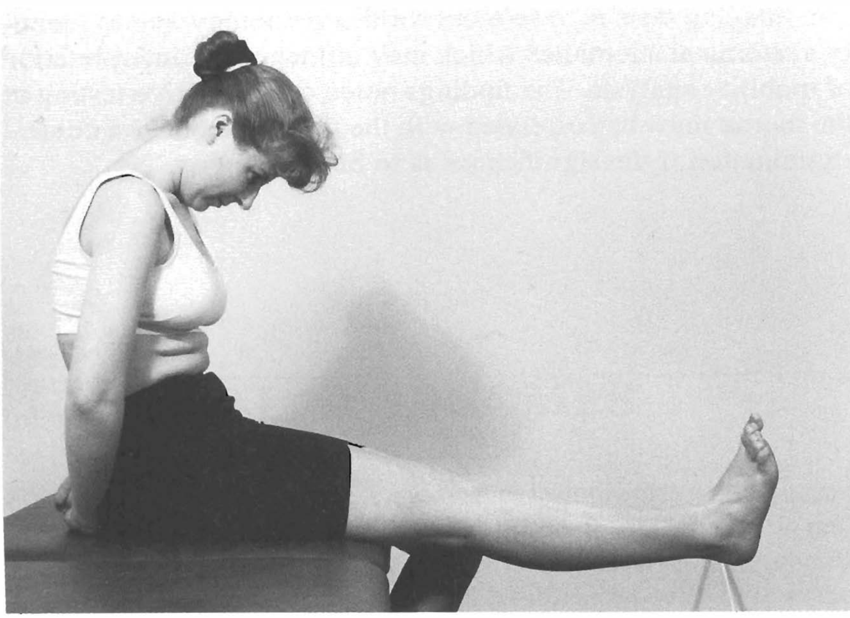


Figure 129.
The slump test.

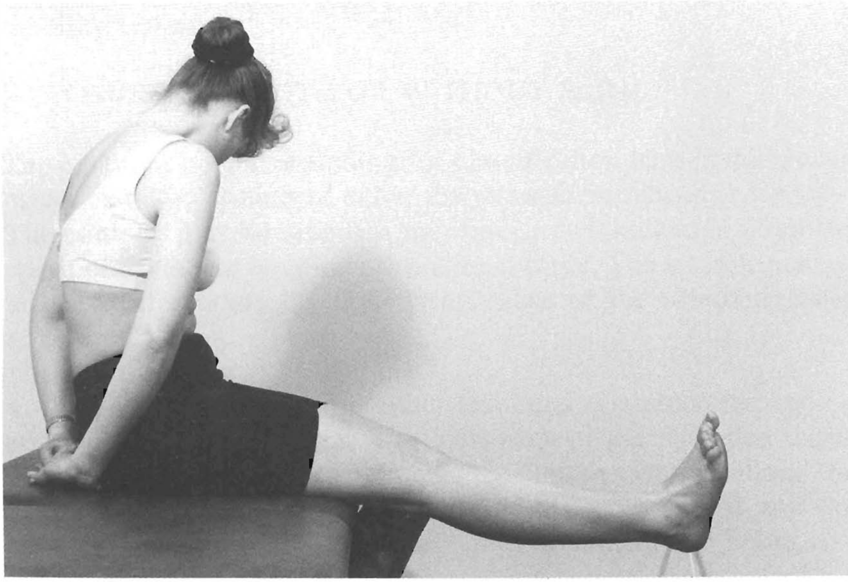


Figure 130.
Modification of the slump test for the detection of segmental neural dysfunction within the thorax.

treatment of articular dysfunction and the reader is referred to Butler's[23] work on this subject for further review.

Adjunctive tests

While X-rays exclude serious bone disease and significant mechanical defects, they rarely provide guidance for manual therapy. Asymmetry is the rule in the thorax and deviation of the spinous processes is to be expected. For the manual therapist, the primary reason for obtaining the results of any adjunctive imaging tests is to rule out serious pathology and to identify anatomical anomalies which may influence the interpretation of mobility analysis. The findings noted on adjunctive testing of the thorax must be correlated with the findings noted on clinical examination if the significance is to be understood.

5

CLINICAL SYNDROMES

This chapter will focus on the mechanical syndromes of the thorax recognizing that referral of pain to the thorax from the viscera, respiratory syndromes, metabolic, infective and neurological conditions may coexist. The model for classification will follow the manual therapy model based on the objective findings noted on mobility testing.

HYPOMOBILITY WITH OR WITHOUT PAIN

The essential objective finding for classification here is *decreased* osteokinematic motion of either the thoracic vertebrae or the ribs. The etiology may be articular, myofascial or both and is often the result of excessive bending or rotational force. The arthrokinematic tests differentiate the underlying cause of the osteokinematic restriction.

The mode of onset may be either insidious or sudden depending upon the degree of trauma. The irritability of the wounded tissue dictates the intensity of the pain, the amount of radiation, the degree of physical activity which tends to aggravate it and the amount of rest required to relieve it. The aim of the subjective examination is to determine the stage and nature of the pathology so that treatment may be adjusted accordingly (Chapter 3).

The location of the pain may be on the ipsilateral or contralateral side of the hypomobility and may radiate around or through to the anterior aspect of the chest. An acute zygapophyseal joint sprain tends to produce very localized pain over the involved joint. A chronic restriction of either the vertebra or rib tends to produce symptoms removed from the source and some of these may be secondary to compensation of the adjacent levels. Referral of pain from the articulations of the thorax tends to be around the chest as opposed to through it. Referral from the intervertebral disc tends to be through the chest.

Magnetic resonance imaging techniques (MRI) have increased the frequency of diagnosis of thoracic disc herniation[24]. Thoracic discs are no longer thought to be an uncommon cause of thoracic pain. In a study by Brown et al[24] the most common symptom in patients with confirmed thoracic disc herniations was anterior chest pain (67%). Other symptoms included lower extremity dysaesthesia and weakness (20%), interscapular pain (8%) and epigastric pain (4%).

> "The degree of herniation was characterized as mild, moderate, or severe. A mild herniation consisted of only minimal dural indentation. Moderate herniation created limited cord pressure with no significant deformation. Severe herniations resulted in free fragments or evidence of cord compression manifested by indentation or flattening of the cord."[24]

The highest incidence according to level was T7-8, the second highest was T6-7 and T9-10.

The sympathetic chain can also refer symptoms into the upper or lower extremity. These patients commonly report temperature changes, heavy sensations associated with fatigue and nonspecific numbness of the involved extremity. The upper thorax can also refer pain into the cranium through the sympathetic pathway.

Hypomobile joints are very consistent in the pattern they present on habitual movement testing. The findings for each joint restriction will be described below. If the joint is truly hypomobile, the arthrokinematic glide will also be restricted. If the myofascia is the source of the restriction, the joint glide will be normal. Disorders in this classification do not exhibit a loss of arthrokinetic function.

The neural/dural mobility tests may be positive if the mobility of the sympathetic chain is effected by a change in position of the head of the rib. Restrictions of the zygapophyseal joint rarely involve the neural/dural tissue.

The thorax will be divided into the anatomical regions for further discussion. The objective mobility/stability findings, the relevant treatment technique and a home exercise will be described.

Vertebromanubrial region

Bilateral restriction of flexion

The upper thorax is rarely fixed in a lordotic position, however, a bilateral restriction of flexion is not uncommon at T2-3. Forward bending of the head will reveal a limitation of the superior excursion of the transverse processes bilaterally confirmed on passive physiological mobility testing. The superior arthrokinematic glide at the zygapophyseal joint will be restricted bilaterally if the dysfunction is intra-articular. The presence or absence of pain depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique. Longitudinal traction of the upper thorax will produce a superior glide of the zygapophyseal joint bilaterally. This technique may be done with the patient either supine lying, sitting or standing. With the patient supine (Fig. 131), grades 1 and 2 techniques can be applied for pain relief. With the lateral aspect of the MCP of the index finger, the interspinous space is palpated at the level to be tractioned. With an open pinch grip of the other hand, the lower cervical spine is palpated as close to the superior vertebra of the level to be tractioned as possible. Localization is achieved by flexing/extending the dysfunctional segment until the neutral position is

Figure 131.
Vertebromanubrial region - bilateral flexion restriction. Longitudinal traction.

Figure 132.
Vertebromanubrial region - bilateral flexion restriction. Longitudinal traction.

ascertained. Grades 1 to 4 longitudinal traction is applied by fixing the caudal vertebra and pulling the cranial vertebra superiorly.

Stronger distraction techniques are done with the patient either sitting or standing with both hands behind the neck, fingers interlaced (Fig. 132). The therapist winds both of their arms beneath the patient's axillae through the triangular space created by the flexed elbows. The fingers are interlaced and placed over the patient's hands. The thorax is gently gripped by adducting the arms. The patient is instructed to look forward and the therapist ensures that the ligamentum nuchae is not on full stretch. From this position, a Grade 3 to 5 longitudinal traction technique is applied by rocking the patient backwards and forwards until a pendular type motion is produced. Gravity provides the distractive force. A high velocity, low amplitude thrust technique (Grade 5) is applied at the apex of the descent when the patient's body weight is dropping.

Home exercise (Fig. 133). To maintain the mobility gained, the patient is instructed to perform the following exercise fre-

Figure 133.
Vertebromanubrial region - bilateral flexion restriction. Home exercise.

quently (up to ten times, ten times per day). With the fingers interlaced behind the neck and the index fingers in the appropriate interspinous space, the patient is instructed to flex the head/neck. The fingers may assist the motion by applying a superior pressure to the inferior aspect of the spinous process of the superior vertebra. The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Unilateral restriction of flexion

This is a common restriction to find in the vertebromanubrial region. A unilateral restriction of flexion will produce a segmental rotoscoliosis as well as a compensatory multisegmental curve above and below the restricted level. Active forward bending of the head will reveal this asymmetry. A unilateral restriction of flexion on the right at T1-2 will produce a right rotation/right sideflexion position of T1 at the limit of forward bending. The left transverse process of T1 will travel further superiorly than the right.

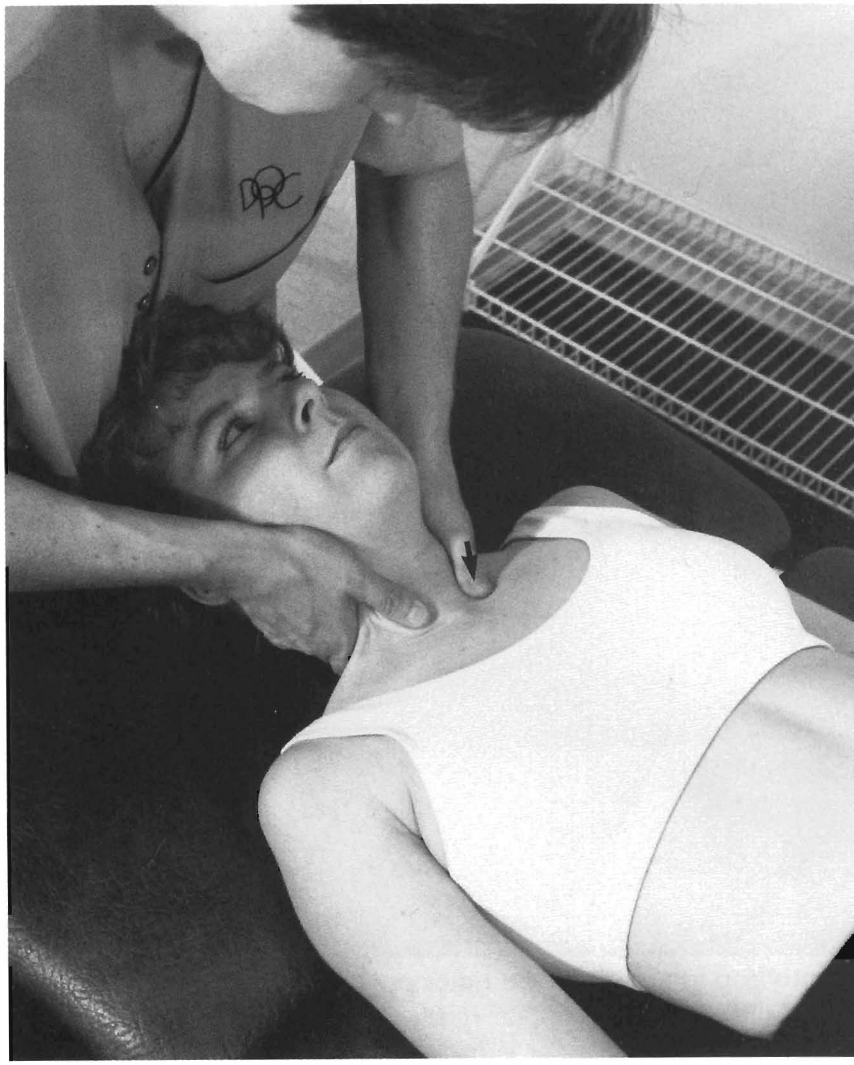


Figure 134.
Vertebromanubrial region - unilateral flexion restriction of the right zygapophyseal joint at T1-2. Mobilization technique.

The right transverse process of T1 will be more dorsal than the left. Left rotation and left lateral bending of the head/neck will be restricted in a consistent pattern in both the H and I combined movement tests. Unilateral elevation of the left arm will produce right sideflexion and left rotation of T1-2. The superior arthrokinematic glide of the right zygapophyseal joint at T1-2 will be restricted if the dysfunction is intra-articular.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique to restore unilateral flexion on the right at T1-2 (Fig. 134). The patient is supine lying with the head supported on a pillow. With the lateral aspect of the index finger, the left transverse process of T1 is palpated. With the other hand, the midcervical spine is supported down to C7. The motion barrier is localized by passively flexing T1-2 and then gliding the left transverse process of T1 inferomedially on T2. C7-T1 is stabilized (locked) with the opposite hand by sideflexing the C7-T1 segment to the left and rotating it to the right. From this position, the right zygapophyseal joint of T1-2 is mobilized into flexion through an inferomedial and slightly posterior glide with the LEFT hand. This will result in a superior and slightly anterior glide of the right facet at T1-2. This is an arthrokinematic mobilization. By restoring the accessory glide the osteokinematic motion (flexion) will be restored. The technique can be graded from 1 to 5.

An active mobilization assist (muscle energy technique) may be used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to resist further motion while the therapist applies a gentle sideflexion force to the head/neck. The isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Home exercise for a restriction of flexion on the right at T1-2. To maintain the mobility gained, the patient is instructed to left rotate the head/neck frequently (up to ten times, ten times per day). Unilateral elevation of the left arm may be used if there are problems with repetitive rotation through the craniovertebral and midcervical regions. The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Bilateral restriction of extension

This restriction is commonly seen when the patient has a forward head posture. Bilateral elevation of the arms will reveal a limitation of the inferior excursion of the transverse processes bilaterally. Rotation and lateral bending of the head/neck often stops at the restriction in the upper thorax thereby placing more stress on the midcervical spine. Unilateral elevation of the arm is markedly restricted on both sides. This restriction places more stress on the clavicular joints and the glenohumeral joint. Passive mobility testing of the inferior and dorsal arthrokinematic glide at the zygapophyseal joint is restricted bilaterally if the dysfunction is intra-articular. The presence or absence of pain depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the

Figure 135.
Vertebromanubrial region - bilateral extension restriction. Mobilization technique.

irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique (Fig. 135). The patient is supine lying with the head supported on a pillow. With the lateral aspect of the index finger of one hand, the interspinous space is palpated at the level to be treated. The opposite hand supports the lower cervical spine as close to the segment as possible. The motion barrier is localized and passively mobilized by dorsally gliding and slightly extending the superior vertebra. This is an arthrokinematic mobilization. By restoring the accessory glide, the osteokinematic motion (extension) will be restored. The technique can be graded from 1 to 4.

An active mobilization assist (muscle energy technique) may be used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to hold still while the therapist gently reduces the support of the head and neck. The isometric contraction of the deep neck flexors is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Home exercise. To maintain the mobility gained, the patient is instructed to elevate the arms bilaterally frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Unilateral restriction of extension

This is another common restriction to find in the vertebromanubrial region. Bilateral elevation of the arms will produce a segmental rotoscoliosis and a compensatory curve above and below the level of restriction. A unilateral restriction of extension on the right at T1-2 will produce a left rotation/left sideflexion position of T1 at the limit of extension. The left transverse process of T1 will travel further inferiorly than the right. The left transverse process of T1 will be more dorsal than the right. Right rotation/sideflexion of the head/neck will be restricted. Unilateral elevation of the right arm will produce left sideflexion and right rotation of T1-2. The inferior arthrokinematic glide of the right zygapophyseal joint at T1-2 will be restricted if the dysfunction is intra-articular.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique to restore unilateral extension on the right at T1-2 (Fig. 136). The patient is supine lying with the head supported on a pillow. With the lateral aspect of the index finger, the right transverse process of T1 is palpated. The midcervical spine is supported down to C7 with the other hand. The motion barrier is localized by passively extending T1-2 and then gliding the right transverse process of T1 inferomedially on T2. C7-T1 is stabilized (locked) with the opposite hand by sideflexing the C7-T1 segment to the right and rotating it to the left. From this position, the right zygapophyseal joint of T1-2 is mobilized into extension through an inferomedial and slightly posterior glide with the

Figure 136.
Vertebromanubrial region - unilateral extension restriction of the right zygapophyseal joint at T1-2. Mobilization technique.

RIGHT hand. This is an arthrokinematic mobilization. By restoring the accessory glide, the osteokinematic motion (extension) will be restored. The technique can be graded from 1 to 5.

An active mobilization assist (muscle energy technique) may be used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to resist further motion while the therapist applies a gentle sideflexion force to the head/neck. The isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Home exercise for a restriction of extension on the right at T1-2. To maintain the mobility gained, the patient is instructed to right rotate the head/neck frequently (up to ten times, ten times per day). Unilateral elevation of the right arm may be used if there are problems with repetitive rotation through the craniovertebral and midcervical regions. The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Unilateral restriction of anterior rotation - first rib

This dysfunction is seen when the scalene muscles are hypertonic or tight and hold the anterior aspect of the first rib superiorly or when the superior glide of the first rib is restricted at the costotransverse joint. This dysfunction will restrict unilateral elevation of the arm (both arms may be involved). If the dysfunction is intra-articular, rotation and lateral bending of the head/neck will be limited to the side of the restricted rib (this motion requires a superior glide of the rib at the costotransverse joint). Full expiration will also reveal asymmetry of rib motion. If the restriction is intra-articular, the superior glide of the first rib at the costotransverse joint will be restricted.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique (Fig. 137). To restore the superior glide of the first rib at the costotransverse joint, the following technique is used. The patient is supine lying with the head supported on a pillow. The superior aspect of the right transverse process of T1 is palpated with the right thumb. The index and middle fingers of the right hand palpate the inferior aspect of the right first rib. The midcervical spine is supported with the other hand. The motion barrier is localized and mobilized by applying a posteroinferior glide to the transverse process of T1 thus producing a relative superior glide of the first rib at the costotransverse joint. The middle and index fingers of the right hand fix the inferior aspect of the first rib. This is an arthrokinematic mobilization aimed at restoring the superior glide of the first rib at the right costotransverse joint. By restoring the accessory glide, the osteokinematic motion (anterior rotation) will be restored. The technique can be graded from 1 to 4.

An active mobilization assist (muscle energy technique) may be used to effect a change in the tone of the scalenus anterior and

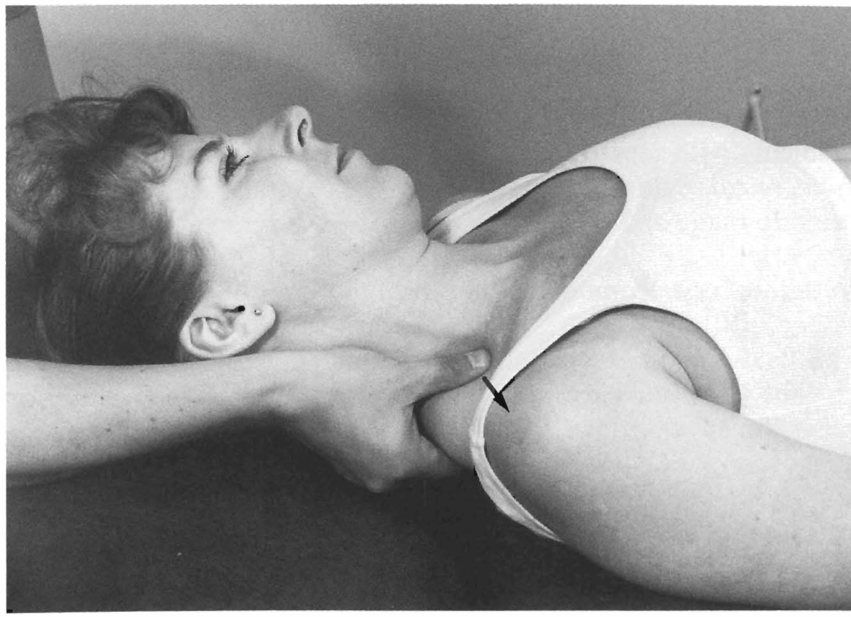
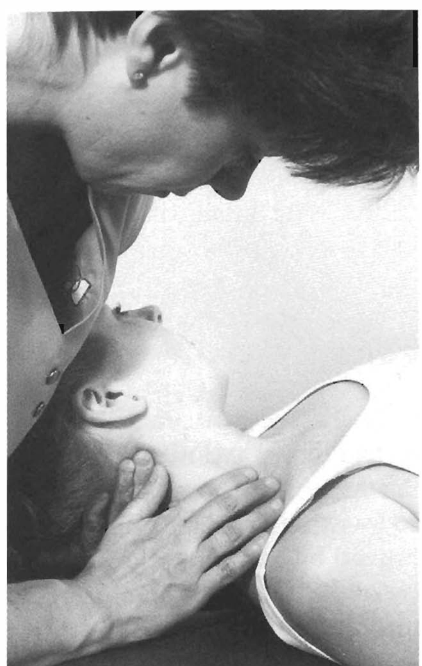


Figure 137.
Vertebromanubrial region - unilateral anterior rotation restriction of the right first costotransverse joint. Mobilization technique.



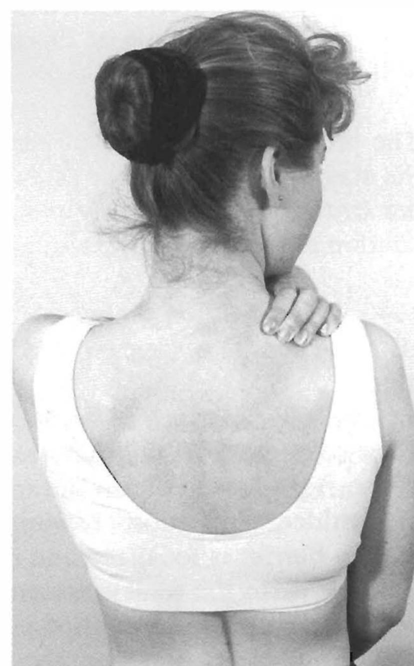


Figure 138.
Vertebromanubrial region - unilateral anterior rotation restriction of the right first costotransverse joint. Active mobilization assist.

Figure 139.
Vertebromanubrial region - unilateral anterior rotation restriction of the right first costotransverse joint. Home exercise.

medius muscles. The head/neck is sideflexed to the right and slightly flexed with the left hand while the right hand monitors the response in the scalene musculature (Fig. 138). The patient is instructed to resist a gentle sideflexion force to the head/neck applied with the left hand. The isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Home exercise for a restriction of anterior rotation of the right first rib (Fig. 139). To maintain the mobility gained, the patient is instructed to fix the posteroinferior aspect of the right first rib with their left hand and to then right rotate the head/neck frequently (up to ten times, ten times per day). By holding the rib posteriorly, the transverse process of T1 glides inferiorly relative to the tubercle of the rib (relative superior glide of the first rib). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Unilateral restriction of posterior rotation - first rib

This dysfunction is seen when the posterior aspect of the first rib is held superiorly or when the inferior glide of the first rib is restricted at the costotransverse joint. This dysfunction will restrict unilateral elevation of the arm on either side, rotation and lateral bending of the head/neck to the opposite side of the restricted rib and full inspiration. If the restriction is intra-articular, the inferior glide of the first rib at the costotransverse joint will be restricted.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique (Fig. 140). To restore the inferior glide of the first rib at the costotransverse joint, the following technique is used. The patient is supine lying with the head supported on a pillow. The superior aspect of the right first rib is palpated with the lateral aspect of the MCP of the index finger of the right hand. The midcervical and upper thoracic spine is supported with the other hand. The spine is locked by localized sideflexion of C7, T1 and T2 to the right and rotation to the left. The motion barrier of the first costotransverse joint is localized and mobilized by applying an anteroinferior glide to the tubercle of the rib allowing the conjunct posterior rotation to occur. This is an arthrokinematic mobilization aimed at restoring the inferior glide of the first rib at the right costotransverse joint. By restoring the accessory glide, the osteokinematic motion (posterior rotation) will be restored. The technique can be graded from 1 to 5.

An active mobilization assist (muscle energy technique) may be used to effect a change in the tone of the segmental muscles. From

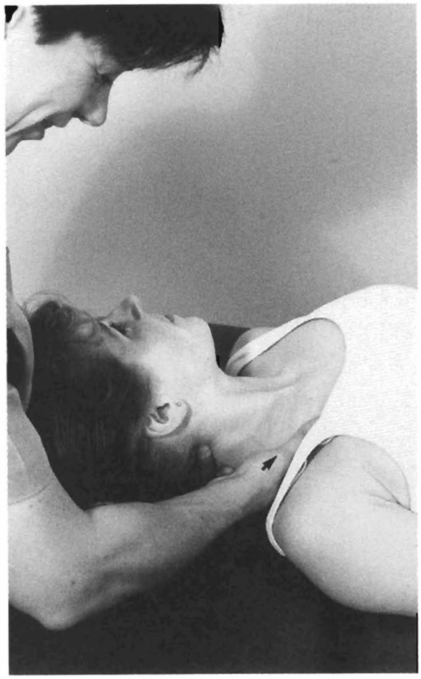


Figure 140.
Vertebromanubrial region - unilateral posterior rotation restriction of the right first costotransverse joint. Mobilization technique.

Figure 141.
Vertebromanubrial region - unilateral posterior rotation restriction of the right first costotransverse joint. Home exercise.

the localized motion barrier, the patient is instructed to resist a gentle sideflexion force to the head/neck applied with the left hand. The isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Home exercise for a restriction of posterior rotation of the right first rib (Fig. 141). To maintain the mobility gained, the patient is instructed to fix the posterosuperior aspect of the right first rib with their left hand and to then left rotate the head/neck frequently (up to ten times, ten times per day). By holding the rib posteriorly, the transverse process of T1 glides superiorly relative to the tubercle of the rib (relative inferior glide of the first rib). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Vertebrosternal and vertebrochondral regions

Bilateral restriction of flexion

A lordotic midthoracic region is often indicative of an underlying breathing dysfunction (Fig. 128). Overactivity of the spinal extensors compensates for a hypertonic diaphragm which tends to flex the thorax. In addition to specifically mobilizing the midthorax it is crucial that the breathing pattern be addressed if a more neutral

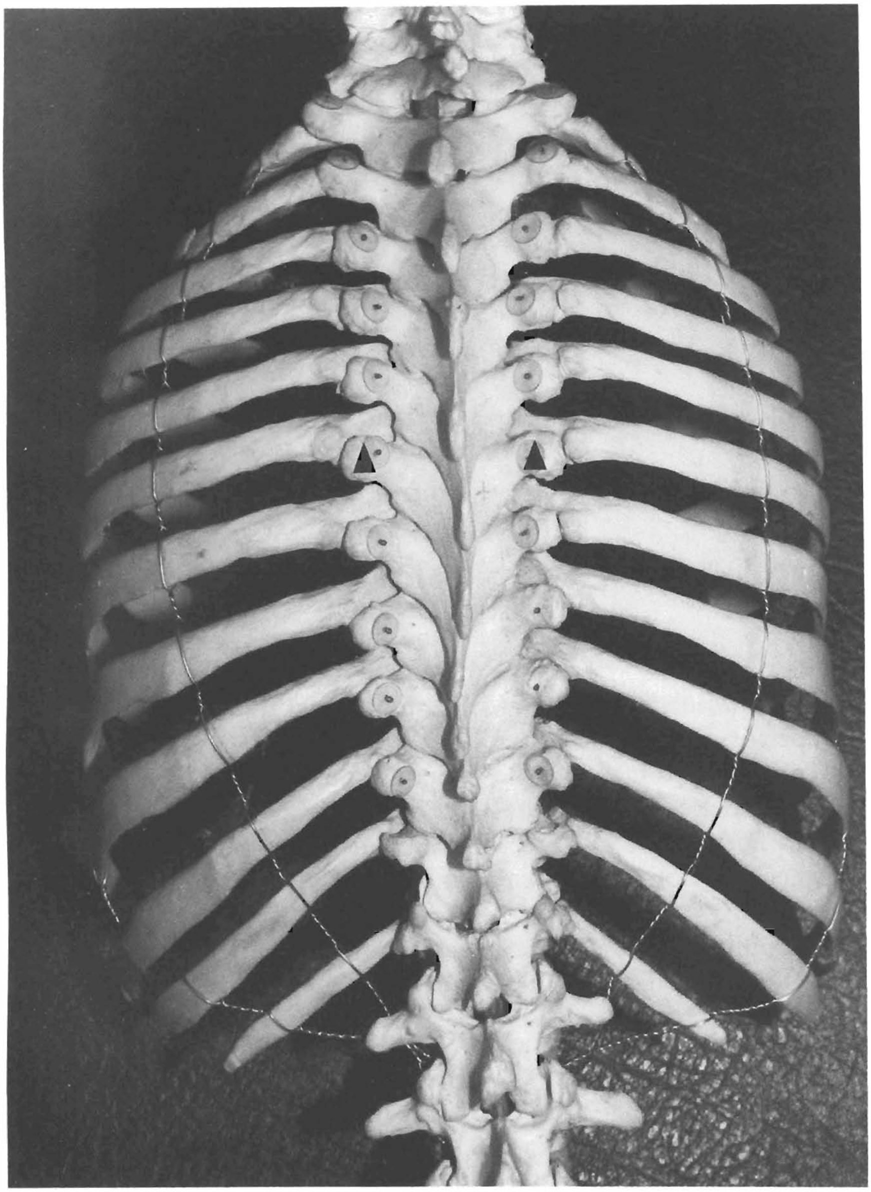


Figure 142.
Vertebrosternal and vertebrochondral region - bilateral flexion restriction - longitudinal traction - points of palpation for the mobilization technique.

position of the spine is to be achieved. When the midthoracic segments (vertebrosternal region) become fixed in extension, active mobility tests of forward bending of the trunk will reveal a limitation of the superior excursion of the transverse processes bilaterally. Passive mobility testing of the superior arthrokinematic glide at the zygapophyseal joint will be restricted bilaterally if the dysfunction is intra-articular.

The presence or absence of pain depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobi-

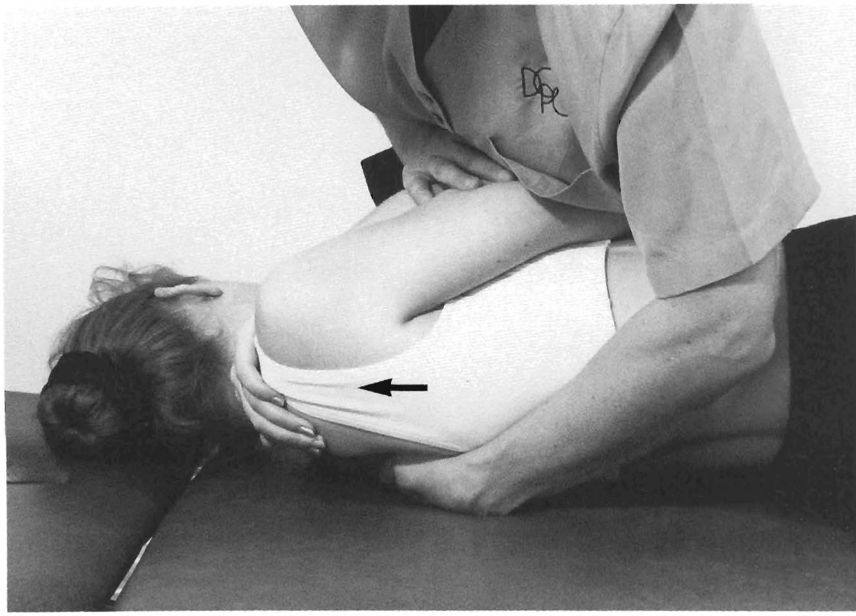


Figure 143.
Vertebrosternal and vertebrochondral region - bilateral flexion restriction - specific longitudinal traction. Mobilization technique.

lization technique is directed by these factors (Chapter 3).

Mobilization technique. Longitudinal traction will produce a superior glide of the zygapophyseal joint bilaterally. This technique may be done with the patient either supine lying or sitting. With the patient supine, grades 1 and 2 techniques are better controlled and can be applied for pain relief. The stronger mobilizations can be done with the patient either supine or sitting.

The supine technique is performed as follows (Figs. 142, 143). The patient is sidelying, the head supported on a pillow and the arms crossed to the opposite shoulders. With the tubercle of the scaphoid bone and the flexed PIP joint of the long finger, the transverse processes of the inferior vertebra are palpated. The other hand/arm lies across the patient's crossed arms to control the thorax. Segmental localization is achieved by flexing the joint to the motion barrier with the hand/arm controlling the thorax. This localization is maintained as the patient is rolled supine *only until contact is made between the table and the dorsal hand.* From this position, longitudinal traction is applied through the thorax to produce a superior glide of the zygapophyseal joint bilaterally. This is an arthrokinematic mobilization. By restoring the accessory glide, the osteokinematic motion will be restored. The technique can be graded from 1 to 5.

An active mobilization assist (muscle energy technique) may be used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to gen-

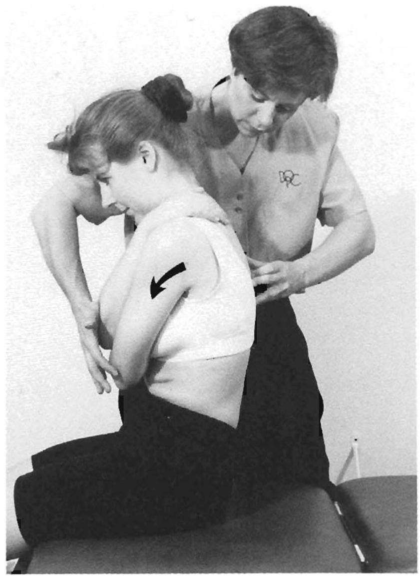


Figure 144.
Vertebrosternal and vertebrochondral region - bilateral flexion restriction - general longitudinal traction. Mobilization technique.

Figure 145.
Vertebrosternal and vertebrochondral region - bilateral flexion restriction. Home exercise.

tly elevate their crossed arms. The motion is resisted by the therapist and the isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Stronger distractive techniques can also be done with the patient sitting with the arms crossed to opposite shoulders (Fig. 144). A small towel is placed against the spinous process of the caudal vertebra of the segment to be distracted. The towel is fixed against the therapist's sternum. With both arms wrapped around the patient's trunk, the patient's elbow which is closest to the chest is grasped. The segment is localized to neutral. From this position, distraction is applied by rocking the patient backwards and simultaneously lifting the thorax posterosuperiorly. The towel fixes the caudal vertebra and assists in localizing the distractive forces to the appropriate segment. The technique can be graded from 3 to 5.

Home exercise (Fig. 145). To maintain the mobility gained, the patient is instructed to perform specific midthoracic flexion frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

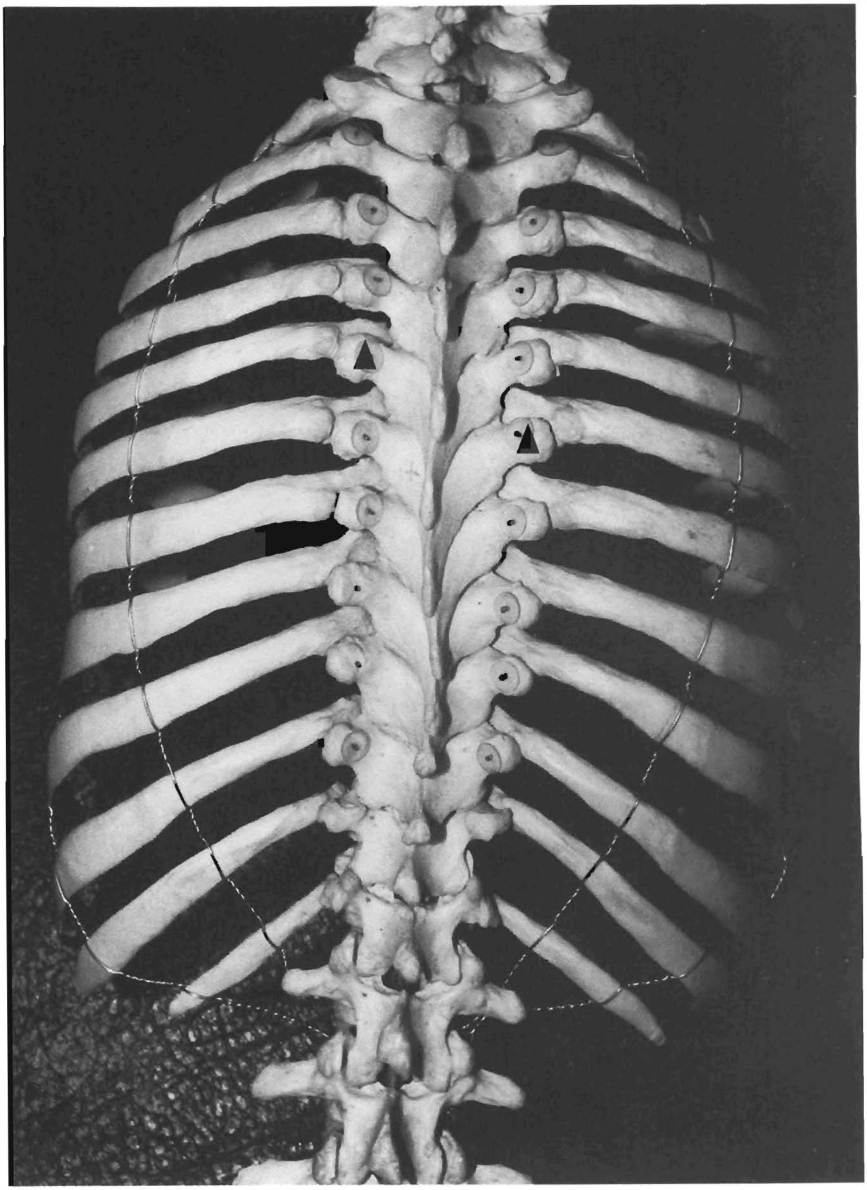


Figure 146.
Vertebrosternal and vertebrochondral region - unilateral flexion/extension restriction of the left zygapophyseal joint at T5-6. Points of palpation for the mobilization technique.

Unilateral restriction of flexion

A unilateral restriction of flexion will produce a segmental rotoscoliosis as well as a compensatory multisegmental curve above and below the restricted level. Active forward bending of the trunk will reveal this asymmetry. A unilateral restriction of flexion on the left at T5-6 will produce a left rotation/left sideflexion position of T5 at the limit of forward bending. The right transverse process of T5 will travel further superiorly than the left. The left transverse process of T5 will be more dorsal than the right. Right rotation and right lateral bending of the trunk will be restricted and produce a

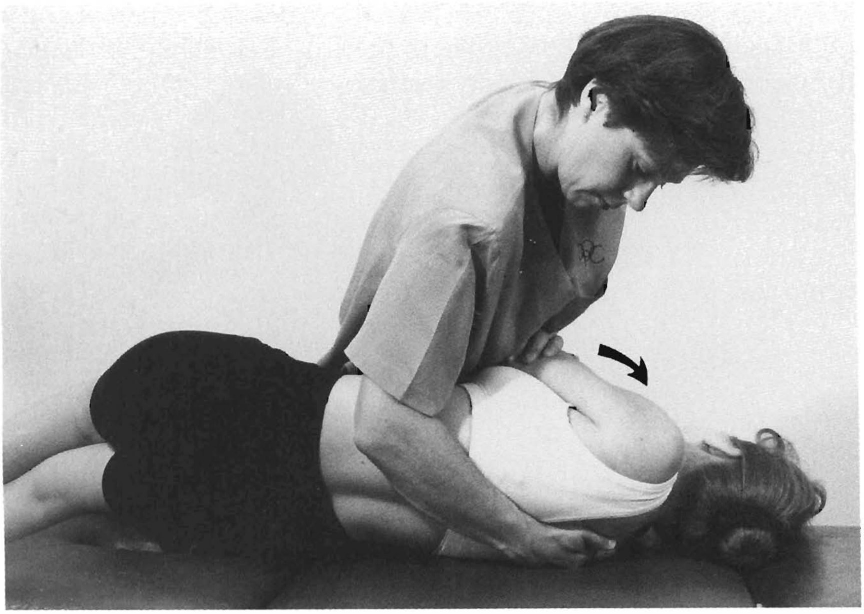


Figure 147.
Vertebrosternal and vertebrochondral region - unilateral flexion restriction of the left zygapophyseal joint at T5-6. Mobilization technique.

kink in the midthoracic curve in a consistent pattern in both the H and I combined movement tests. The superior arthrokinematic glide of the left zygapophyseal joint at T5-6 will be restricted if the dysfunction is intra-articular.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique to restore unilateral flexion on the left at T5-6 (Figs. 146, 147). The patient is right sidelying, the head supported on a pillow and the arms crossed to the opposite shoulders. With the tubercle of the right scaphoid bone and the flexed PIP joint of the right long finger, the left transverse process of T6 and the right transverse process of T5 are palpated. The other hand/arm lies across the patient's crossed arms to control the thorax. Segmental localization is achieved by flexing the joint to the motion barrier with the hand/arm controlling the thorax. This localization is maintained as the patient is rolled supine *only until contact is made between the table and the dorsal hand.* From this position, a right sideflexion force is applied through the thorax to produce a superior glide of the left zygapophyseal joint. This is an arthrokinematic mobilization. By restoring the accessory glide, the osteokinematic motion will be restored. The technique can be graded from 1 to 5.

An active mobilization assist (muscle energy technique) may be

Figure 148.
Vertebrosternal and vertebrochondral region - unilateral flexion restriction of the left zygapophyseal joint at T5-6. Active mobilization assist.

Figure 149.
Vertebrosternal and vertebrochondral region - unilateral flexion restriction of the left zygapophyseal joint at T5-6. Home exercise.

used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to gently elevate their crossed arms. The motion is resisted by the therapist and the isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

When the myofascia is thought to be the main cause of the osteokinematic restriction the following technique can be useful (Fig. 148). The patient is sitting with the arms crossed to opposite shoulders. With the dorsal hand the intertransverse space is palpated. The ventral hand is placed on the contralateral shoulder. The motion barrier is localized by flexing and right sideflexing the thorax. From this position, the patient is instructed to hold still while the therapist applies resistance to the trunk. The direction of the applied resistance is determined by the neurophysiological effect desired from the technique. A hold/relax technique applies the principles of autogenic inhibition and is used primarily for a contractured muscle. The involved muscle is recruited strongly and then maximally stretched in the immediate post-contraction relaxation phase. A contract/relax technique applies the principles of reciprocal inhibition and is used primarily for a hypertonic muscle. The antagonist muscle is recruited gently. The contraction results in reciprocal inhibition of the antagonistic hypertonic muscle.

The isometric contraction is held for up to 5 seconds following which the patient is instructed to completely relax. The new flexion/sideflexion barrier is localized and the mobilization repeated three times.

Home exercise (Fig. 149). To maintain the mobility gained, the patient is instructed to perform specific midthoracic right sideflexion in slight flexion frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Unilateral restriction of extension

A unilateral restriction of extension will produce a segmental rotoscoliosis as well as a compensatory multisegmental curve above and below the restricted level. Active backward bending of the trunk will reveal this asymmetry. A unilateral restriction of extension on the left at T5-6 will produce a right rotation/right sideflexion position of T5 at the limit of backward bending. The right transverse process of T5 will travel further inferiorly than the left. The right transverse process of T5 will be more dorsal than the right. Left rotation and left lateral bending of the trunk will be restricted and produce a kink in the midthoracic curve in a consistent pattern in both the H and I combined movement tests. The inferior arthrokinematic glide of the left zygapophyseal joint at T5-6 will be restricted if the dysfunction is intra-articular.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique to restore unilateral extension on the left at T5-6 (Figs. 146, 150). The patient is right sidelying, the head supported on a pillow and the arms crossed to the opposite shoulders. With the tubercle of the right scaphoid bone and the flexed PIP joint of the right long finger, the left transverse process of T6 and the right transverse process of T5 are palpated. The other hand/arm lies across the patient's crossed arms to control the thorax. Segmental localization is achieved by extending the joint to the motion barrier with the hand/arm controlling the thorax. This localization is maintained as the patient is rolled supine only until contact is made between the table and the dorsal hand. From this position, a left sideflexion force (coupled with a slight dorsal glide) is applied through the thorax to produce an inferior glide of the left zygapophyseal joint. This is an arthrokinematic mobilization. By

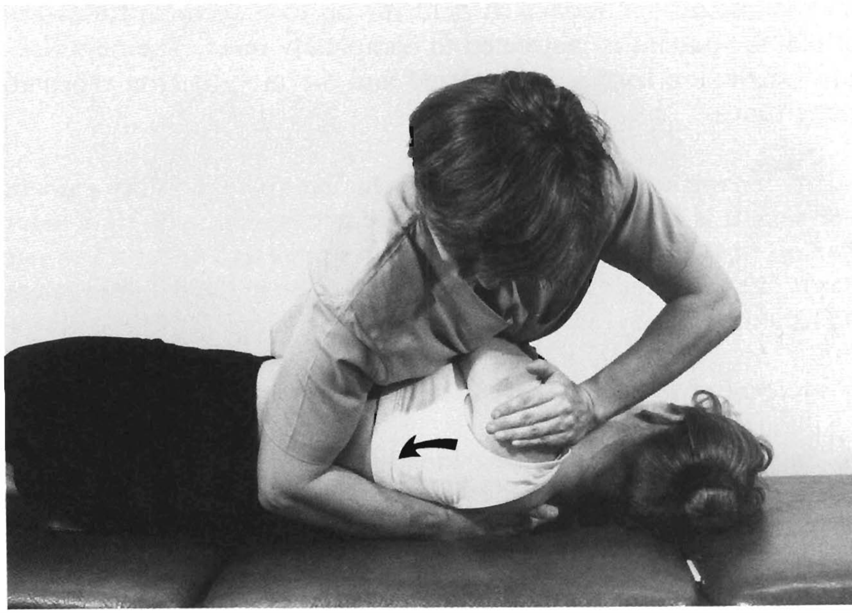


Figure 150.
Vertebrosternal and vertebrochondral region - unilateral extension restriction of the left zygapophyseal joint at T5-6. Mobilization technique.

restoring the accessory glide, the osteokinematic motion will be restored. The technique can be graded from 1 to 5.

An active mobilization assist (muscle energy technique) may be used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to gently elevate their crossed arms. The motion is resisted by the therapist and the isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

When the myofascia is thought to be the main cause of the osteokinematic restriction the following technique can be useful (Fig. 151). The patient is sitting with the arms crossed to opposite shoulders. With the dorsal hand the intertransverse space is palpated. The ventral hand is placed on the contralateral shoulder. The motion barrier is localized by extending and left sideflexing the thorax. From this position, the patient is instructed to hold still while the therapist applies resistance to the trunk. The direction of the applied resistance is determined by the neurophysiological effect desired from the technique. A hold/relax technique applies the principles of autogenic inhibition and is used primarily for a contractured muscle. The involved muscle is recruited strongly and then maximally stretched in the immediate post-contraction relaxation phase. A contract/relax technique applies the principles of reciprocal inhibition and is used primarily for a hypertonic muscle.

Figure 151.
Vertebrosternal and vertebrochondral region - unilateral extension restriction of the left zygapophyseal joint at T5-6. Active mobilization assist.

Figure 152.
Vertebrosternal and vertebrochondral region - unilateral extension restriction of the left zygapophyseal joint at T5-6. Home exercise.

The antagonist muscle is recruited gently. The contraction results in reciprocal inhibition of the antagonistic hypertonic muscle.

The isometric contraction is held for up to 5 seconds following which the patient is instructed to completely relax. The new extension/sideflexion barrier is localized and the mobilization repeated three times.

Home exercise (Fig. 152). To maintain the mobility gained, the patient is instructed to perform specific midthoracic left sideflexion in slight extension frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Unilateral restriction of rotation (posterior or anterior) - ribs 3 to 10

This dysfunction is seen when the muscles are imbalanced or when the arthrokinematic glide of the rib is restricted at the costotransverse joint (Figs. 153, 154). The clinician must be aware of relative flexibility between the thoracic vertebrae and the ribs when interpreting the findings on habitual movement tests and passive arthrokinematic mobility tests. The direction of the costotransverse joint glide can be either superior or inferior during forward and backward bending. The patient's normal pattern must be ascertained before the findings can be understood. Respiration produces the most consistent movement pattern and is the most reliable

Figure 153.
Left rotation of the midthorax is fairly free even in the presence of a marked scoliosis secondary to poliomyelitis.

Figure 154.
Right rotation of the midthorax is blocked due to the inability of the right sixth rib to posteriorly rotate.

habitual movement to test when evaluating osteokinematic function of the ribs. If the dysfunction is intra-articular the arthrokinematic glide of the costotransverse joint will be reduced.

Active mobilization techniques are useful when the myofascia is imbalanced. Respiration may produce asymmetry in the thorax but the arthrokinematic glide of the costotransverse joint is normal.

Mobilization technique to restore posterior rotation right fifth rib (Fig. 155). When the myofascia is thought to be the main cause of the osteokinematic restriction the following technique can be useful. The patient is sitting with the arms crossed to opposite shoulders. With the dorsal hand the fifth rib is palpated. The ventral hand is placed on the patient's contralateral shoulder. The motion barrier is localized by left sideflexing and right rotating the thorax. From this position, the patient is instructed to hold still while the therapist applies resistance to the trunk. The direction of the applied resistance is determined by the neurophysiological effect desired from the technique. A hold/relax technique applies the principles of autogenic inhibition and is used primarily for a contractured muscle. The involved muscle is recruited strongly and then maximally stretched in the immediate post-contraction relaxation phase. A contract/relax technique applies the principles of reciprocal inhibition and is used primarily for a hypertonic muscle. The antagonist muscle is recruited gently. The contraction results in reciprocal inhibition of the antagonistic hypertonic muscle.

Figure 155.
Vertebrosternal and vertebrochondral region - unilateral restriction of posterior rotation of the right fifth rib. Active mobilization technique.

Figure 156.
Vertebrosternal and vertebrochondral region - unilateral restriction of anterior rotation of the right fifth rib. Active mobilization technique.

The isometric contraction is held for up to 5 seconds following which the patient is instructed to completely relax. The new motion barrier is localized and the mobilization repeated three times.

Home exercise. To maintain the mobility gained, the patient is instructed to perform specific midthoracic left sideflexion and right rotation frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Mobilization technique to restore anterior rotation right fifth rib (Fig. 156). The patient is sitting with the arms crossed to opposite shoulders. With the dorsal hand the fifth rib is palpated. The ventral hand is placed on the patient's contralateral shoulder. The motion barrier is localized by right sideflexing and left rotating the thorax. From this position, the patient is instructed to hold still while the therapist applies resistance to the trunk. The direction of the applied resistance is determined by the neurophysiological effect desired from the technique. A hold/relax technique applies the principles of autogenic inhibition and is used primarily for a contractured muscle. The involved muscle is recruited strongly and then maximally stretched in the immediate post-contraction relaxation phase. A contract/relax technique applies the principles of reciprocal inhibition and is used primarily for a hypertonic muscle. The antagonist muscle is recruited gently. The contraction

Figure 157.
Vertebrosternal and vertebrochondral region - unilateral restriction of anterior rotation of the right fifth rib. Home exercise.

results in reciprocal inhibition of the antagonistic hypertonic muscle.

The isometric contraction is held for up to 5 seconds following which the patient is instructed to completely relax. The new motion barrier is localized and the mobilization repeated three times.

Home exercise (Fig. 157). To maintain the mobility gained, the patient is instructed to perform specific midthoracic right sideflexion and left rotation frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Thoracolumbar junction

Unilateral restriction of flexion

A unilateral restriction of flexion in the thoracolumbar junction will produce a segmental rotoscoliosis as well as a compensatory

Figure 158.
Thoracolumbar junction - unilateral restriction of flexion of the right zygapophyseal joint at T11-12. Mobilization technique.

multisegmental curve above and below the restricted level. Active forward bending of the trunk will reveal this asymmetry. A unilateral restriction of flexion on the right at T11-12 will produce a right rotation/right sideflexion position of T11 at the limit of forward bending. Left rotation and left lateral bending of the trunk will be restricted in a consistent pattern in both the H and I combined movement tests. The superior arthrokinematic glide of the right zygapophyseal joint at T11-12 will be restricted if the dysfunction is intra-articular.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique to restore unilateral flexion on the right at T11-12 (Fig. 158). With the patient in left sidelying, hips and knees slightly flexed, the T10-11 interspinous space is palpated. The thoracolumbar spine is rotated through the patient's lower arm until full rotation of T10-11 is achieved. The L1-2 interspinous space is palpated and the patient's uppermost hip and knee are flexed until full flexion of L1-2 occurs. The foot of the upper leg rests against the popliteal fossa of the lower leg. The T11-12 interspinous space is palpated and the right zygapophyseal joint is localized and mobilized into flexion and left sideflexion through either the thorax or the pelvic girdle. The technique can be graded from 1 to 5.

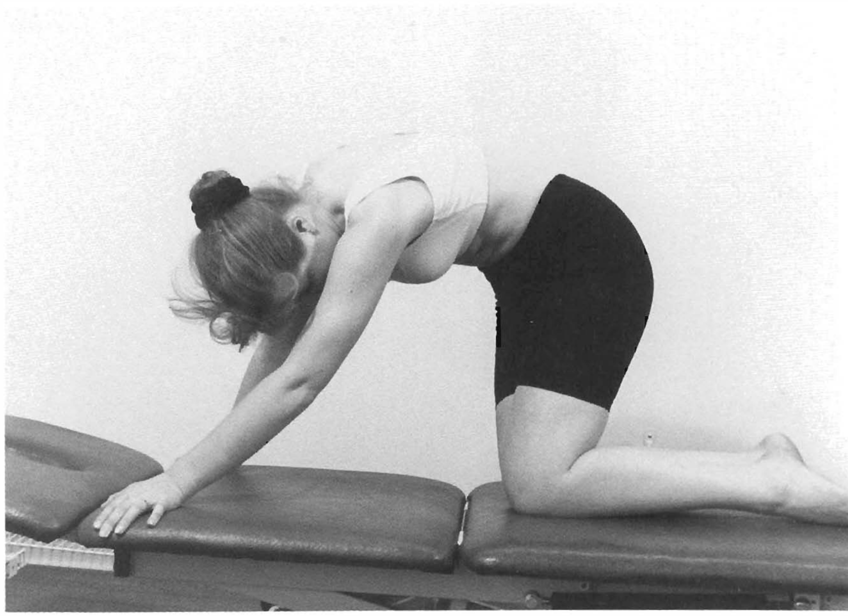


Figure 159.
Thoracolumbar junction - unilateral restriction of flexion of the right zygapophyseal joint at T11-12. Home exercise.

An active mobilization assist (muscle energy technique) may be used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to gently resist further sideflexion of the trunk. The isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Home exercise (Fig. 159). To maintain the mobility gained, the patient is instructed to perform specific thoracolumbar flexion and left sideflexion in a four point kneeling position frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the painfree range and should not aggravate any symptoms.

Unilateral restriction of extension

A unilateral restriction of extension in the thoracolumbar junction will produce a segmental rotoscoliosis as well as a compensatory multisegmental curve above and below the restricted level. Active backward bending of the trunk will reveal this asymmetry. A unilateral restriction of extension on the right at T11-12 will produce a left rotation/left sideflexion position of T11 at the limit of backward bending. Right rotation and right lateral bending of the trunk will be restricted in a consistent pattern in both the H and I combined movement tests (Fig. 160). The inferior arthrokinematic glide of the right zygapophyseal joint at T11-12 will be restricted

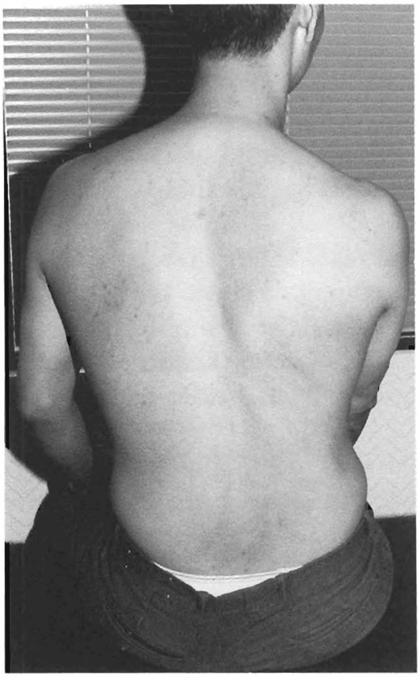


Figure 160.
Thoracolumbar junction - unilateral restriction of extension of the right zygapophyseal joint at T11-12 will completely block the formation of the S curve during rotation of the trunk.

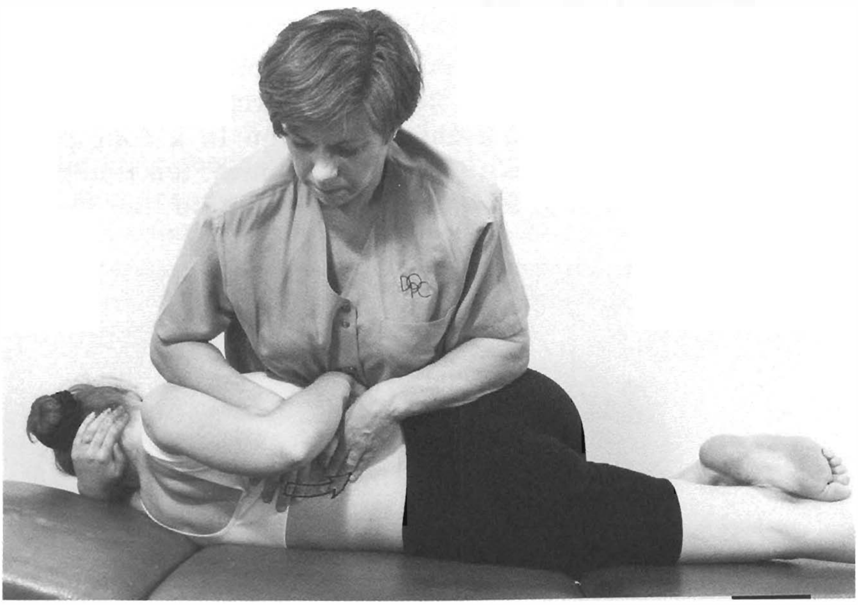


Figure 161.
Thoracolumbar junction - unilateral restriction of extension of the right zygapophyseal joint at T11-12. Mobilization technique.

if the dysfunction is intra-articular.

The presence or absence of pain during these tests depends upon the stage of the pathology (substrate, fibroblastic, maturation) and the irritability of the surrounding tissue. The grade of the mobilization technique is directed by these factors (Chapter 3).

Mobilization technique to restore unilateral extension on the right at T11-12 (Fig. 161). With the patient in left sidelying, hips and knees slightly flexed, the T10-11 interspinous space is palpated. The thoracolumbar spine is rotated through the patient's lower arm until full rotation of T10-11 is achieved. The L1-2 interspinous space is palpated and the patient's uppermost hip and knee are flexed until full flexion of L1-2 occurs. The foot of the upper leg rests against the popliteal fossa of the lower leg. The T11-12 interspinous space is palpated and the right zygapophyseal joint is localized and mobilized into extension and right sideflexion through either the thorax or the pelvic girdle. The technique can be graded from 1 to 5.

An active mobilization assist (muscle energy technique) may be used to effect a change in the muscle tone segmentally. When the motion barrier has been localized, the patient is instructed to gently resist further sideflexion of the trunk. The isometric contraction is held for up to five seconds followed by a period of complete relaxation. The joint is then passively taken to the new motion barrier, the technique is repeated three times and followed by re-evaluation of osteokinematic function.

Home exercise (Fig. 162). To maintain the mobility gained, the patient is instructed to perform specific thoracolumbar extension and right sideflexion in a four point kneeling position frequently (up to ten times, ten times per day). The amplitude of the exercise should be in the

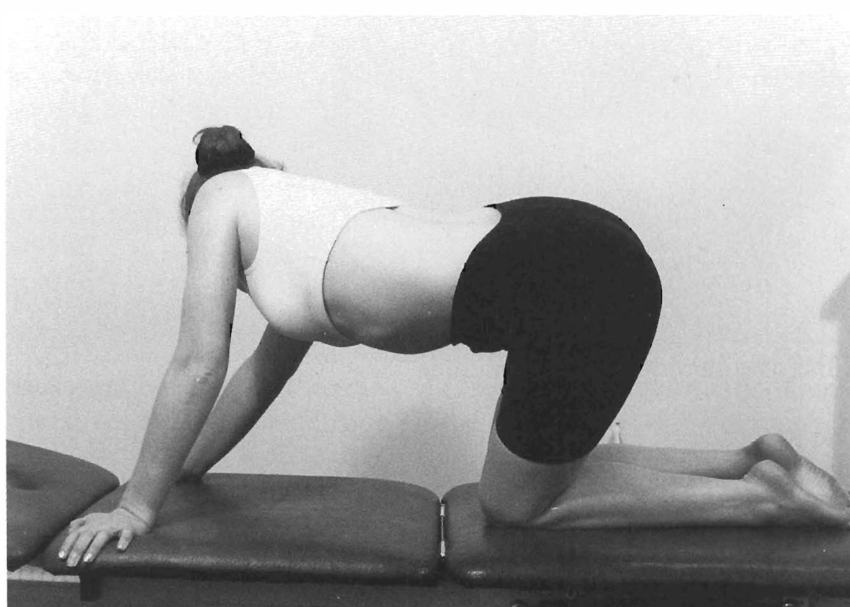


Figure 162.
Thoracolumbar junction - unilateral restriction of extension of the right zygapophyseal joint at T11-12. Home exercise.

painfree range and should not aggravate any symptoms.

HYPERMOBILITY WITH OR WITHOUT PAIN

Hypermobility can be the result of major trauma over a short period of time or minor repetitive trauma over a long period of time. The essential objective finding for classification here is the presence of increased osteokinematic motion of either the thoracic vertebrae or ribs.

The mode of onset may be either insidious or sudden depending upon the degree of trauma. The irritability of the wounded tissue dictates the intensity of the pain, the amount of radiation, the degree of physical activity which tends to aggravate it and the amount of rest required to relieve it. The aim of the subjective examination is to determine the stage and nature of the pathology so that treatment may be adjusted accordingly (Chapter 3).

An acute subluxation of either a rib or 'a ring' (see below) tends to produce very localized pain over the involved joint. In longstanding conditions, the location of the pain is poorly localized to a specific segment and tends to radiate over a region of the thorax. Referral of pain is variable and can be either around the chest or through it.

If the sympathetic chain is effected by the hypermobile segment, symptoms can be referred into the upper or lower extremity. These patients commonly report temperature changes, heavy sensations associated with fatigue and nonspecific numbness of the involved extremity. The upper thorax can also refer pain into the cranium through the sympathetic pathway.

Hypermobile joints are very inconsistent in the pattern they present on habitual movement testing. The active mobility tests reveal an abnormal movement pattern which is variable depending upon the order in which the combined movements are performed. Specific mobility and stability testing reveals the hypermobility/instability since disorders in this classification exhibit a loss of arthrokinetic function. The neural/dural mobility tests may be positive if the mobility of the sympathetic chain is effected by a change in position of the head of the rib.

Subluxation of the costotransverse and costovertebral joints

Subluxations of the costotransverse joints are not uncommon and occur secondary to rotational trauma or a direct blow to the chest.

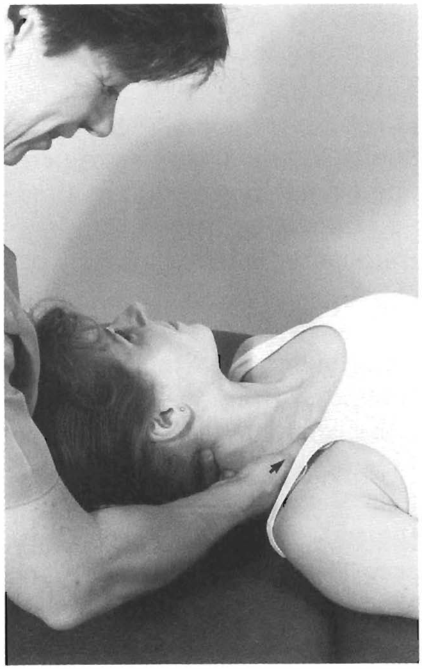


Figure 163.
Vertebromanubrial region - unilateral superior subluxation of the right first rib at the costotransverse joint. Mobilization technique.

The rib will be either superior or inferior on positional testing and all movements including the arthrokinematic glides are blocked. The joint is hypomobile until the subluxation is reduced. Following reduction of the subluxation, the arthrokinetic tests for stability reveal the underlying hypermobility of the rib. Stabilization is then required. The treatment technique to reduce a subluxed costotransverse joint is a grade 5 distraction technique.

Vertebromanubrial region

Mobilization technique for a superiorly subluxed right first rib at the costotransverse joint (Fig. 163). To restore the inferior glide of the first rib at the costotransverse joint, the following technique is used. The patient is supine lying with the head supported on a pillow. The superior aspect of the right first rib is palpated with the lateral aspect of the MCP of the index finger of the right hand. The midcervical and upper thoracic spine is supported with the other hand. The spine is locked by localized sideflexion of C7, T1 and T2 to the right and rotation to the left. The motion barrier of the first costotransverse joint is localized by applying an anteroinferior glide to the tubercle of the rib. From this position a high velocity, low amplitude thrust is applied to the first rib in an anteromedial direction.

If the reduction is successful, the arthrokinematic glide at the costotransverse joint will be restored. An active mobilization technique (see hypomobile classification) may be required to attain myofascial balance and optimal osteokinematic function.

Anteriorly, the costochondral and sternochondral joints can become hypermobile/unstable and a source of localized anterior chest pain. Causes include excessive rotational trauma and/or a direct blow to the anterior chest. There is a palpable step or gap between the rib/cartilage or the cartilage/sternum, the arthrokinetic test reveals a greater amplitude of movement and is associated with local tenderness. When the two joint surfaces are displaced or subluxed, reduction is not possible. The acute joint is treated with

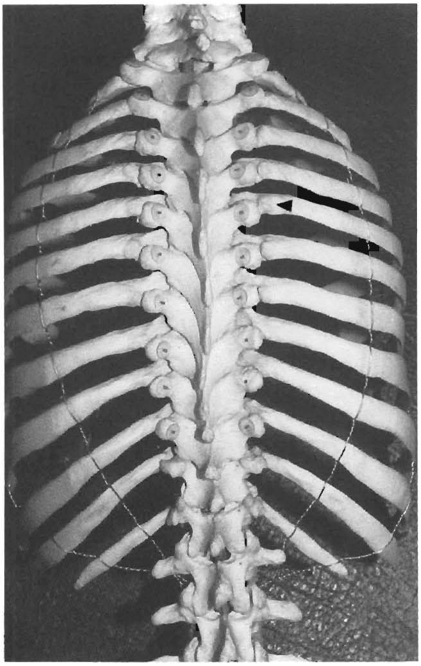


Figure 164.

Vertebrosternal and vertebrochondral region - unilateral subluxation of the right fifth rib at the costotransverse joint. Point of palpation for fixation of the rib.

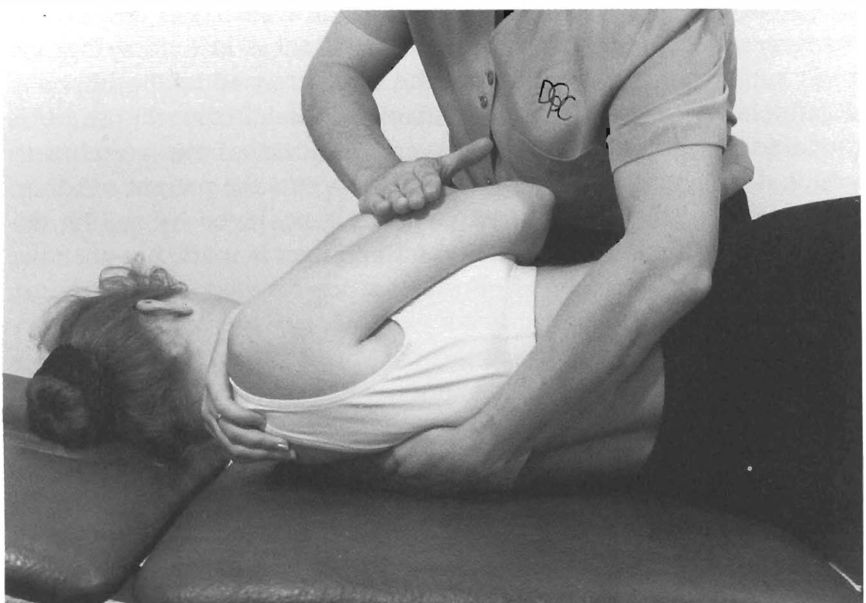


Figure 165.

Vertebrosternal and vertebrochondral region - unilateral subluxation of the right fifth rib at the costotransverse joint. Supine mobilization technique.

rest, education regarding limiting the use of the shoulder (to avoid further separation of the joint with contraction of the serratus anterior and/or pectoralis major/minor muscles), local electrotherapeutic modalities for pain relief and control of inflammation and taping to limit motion of the thorax.

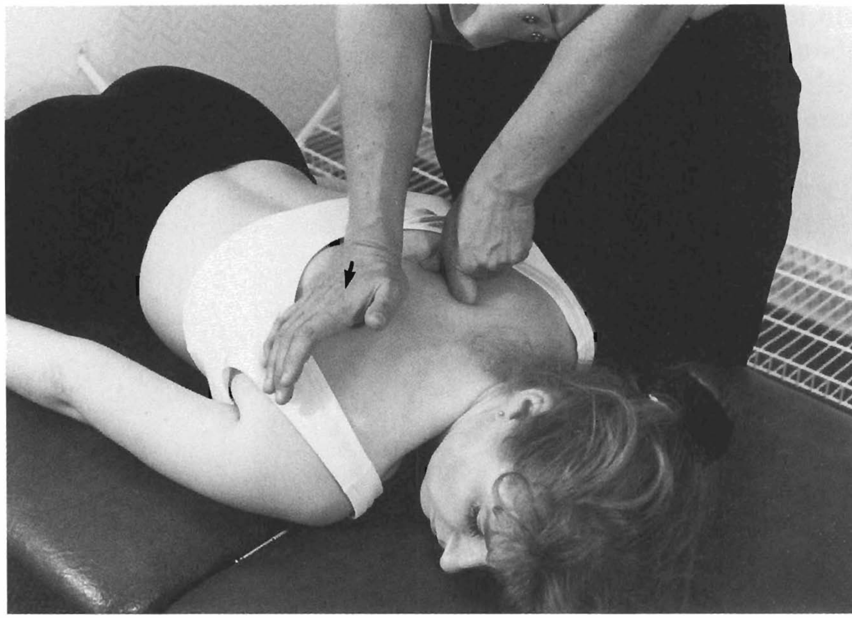


Figure 166.
Vertebrosternal and vertebrochondral region - unilateral subluxation of the right fifth rib at the costotransverse joint. Prone mobilization technique.

Vertebrosternal and vertebrochondral regions

Mobilization technique for the subluxed right fifth costotransverse joint (Figs. 164, 165). The patient is left sidelying, the head supported on a pillow and the arms crossed to the opposite shoulders. With the proximal phalanx of the left thumb, the rib is palpated just lateral to the transverse process of the vertebra to which it attaches. The other hand/arm supports the patient's thorax. Distraction of the costotransverse joint is achieved by rolling the patient over the dorsal hand only until contact is made between the table and the dorsal hand. Further axial rotation of the thorax against the fixed rib will distract the costotransverse joint. A very low amplitude, high velocity thrust applied through the thorax in axial rotation will reduce the subluxation.

Alternately, the technique can be done with the patient prone lying (Fig. 166). To distract the right fifth rib, the left transverse processes of T4 and T5 are fixed with the left hand. With the other hand, the fifth rib is palpated just lateral to the transverse process of T5. If the subluxation is superior, the cranial aspect of the rib is palpated. If the subluxation is inferior, the caudal aspect of the rib is palpated. The rib is distracted at the costotransverse joint by applying a posteroanterior pressure while fixing the transverse processes of T4 and T5. A high velocity, low amplitude thrust is applied through the rib in a superior or inferior direction depending upon the direction of the subluxation.

If the reduction is successful, the arthrokinematic glide at the costotransverse joint will be restored. An active mobilization technique (see hypomobile classification) may be required to attain myofascial balance and optimal osteokinematic function.

Anteriorly, the costochondral and sternochondral joints can also become hypermobile/unstable and a source of localized anterior chest pain. The causes, findings and treatment have been discussed in the vertebromanubrial section.

Thoracolumbar junction

Subluxation of the eleventh or twelfth ribs at the costovertebral joint is not common given the flexibility of the region. A sudden contraction of the fully stretched quadratus lumborum muscle (hyperextension from the fully flexed position) can sublux the twelfth rib inferiorly. Excessive rotation of the trunk while fully flexed can also sublux these joints.

When acute, the patient presents with a lateral shift of the trunk localized to the thoracolumbar junction. All active movements are blocked at the thoracolumbar junction. Any attempt to correct the lateral shift meets with resistance and an increase in the patient's pain. The lumbar myofascia is hypertonic on the side of the lateral shift. The subluxed costovertebral joint is extremely tender to local palpation of the soft tissue overlying the joint. Specific mobility testing reveals a reduction in the arthrokinematic glide of the zygapophyseal joints between T11-12 or T12-L1 and a com-

Figure 167.
Thoracolumbar junction - unilateral subluxation of the right twelfth rib at the costovertebral joint. Mobilization technique.

plete block of any glide between the subluxed rib and its associated vertebra. The treatment technique to reduce a subluxed costotransverse joint is a grade 5 distraction technique.

Mobilization technique to reduce a subluxed right twelfth costovertebral joint (Fig. 167). With the patient in left sidelying, hips and knees slightly flexed, the T12-L1 interspinous space is palpated. The thoracolumbar spine is rotated through the patient's lower arm until full rotation of T12-L1 is achieved. The L1-2 interspinous space is palpated and the patient's uppermost hip and knee are flexed until full flexion of L1-2 occurs. The foot of the upper leg rests against the popliteal fossa of the lower leg. The right side of the spinous process of T12 is palpated with the therapist's cranial hand. The right twelfth rib is palpated and fixed with the thumb and index finger of the therapist's left hand. The right costovertebral joint between the twelfth rib and T12 is distracted with a high velocity, low amplitude thrust technique by axially rotating the spinous process of T12 away from the fixed rib.

If the reduction is successful, the arthrokinematic glide at the costotransverse joint will be restored. An active mobilization technique (see hypomobile classification) may be required to attain myofascial balance and optimal osteokinematic function.

Subluxation of the 'Ring'

This subluxation involves the entire 'ring' which includes two adjacent thoracic vertebrae, the intervertebral disc, the two ribs and their associated anterior and posterior joints and the sternum. This subluxation occurs primarily in the vertebrosternal region and occasionally in the vertebrochondral region. It can occur when excessive rotation is applied to the unrestrained thorax or when rotation of the thorax is forced against a fixed rib cage (seat belt injury). At the limit of right rotation in the midthorax the superior vertebra has translated to the left, the left rib has translated posterolaterally and the right rib has translated anteromedially such that a functional U joint is produced (Chapter 2). Further right rotation results in a right lateral tilt of the superior vertebra. Subluxation of the superior vertebra occurs when the left lateral translation exceeds the physiological motion barrier and the vertebra is unable to return to its neutral position. For the subluxation to occur it is proposed that a horizontal cleft through the posterior 1/3 of the intervertebral disc must occur (Fig. 168).

Positionally, the following findings are noted with a left lateral shift subluxation of the sixth ring (T5-T6 and the sixth ribs). T5-

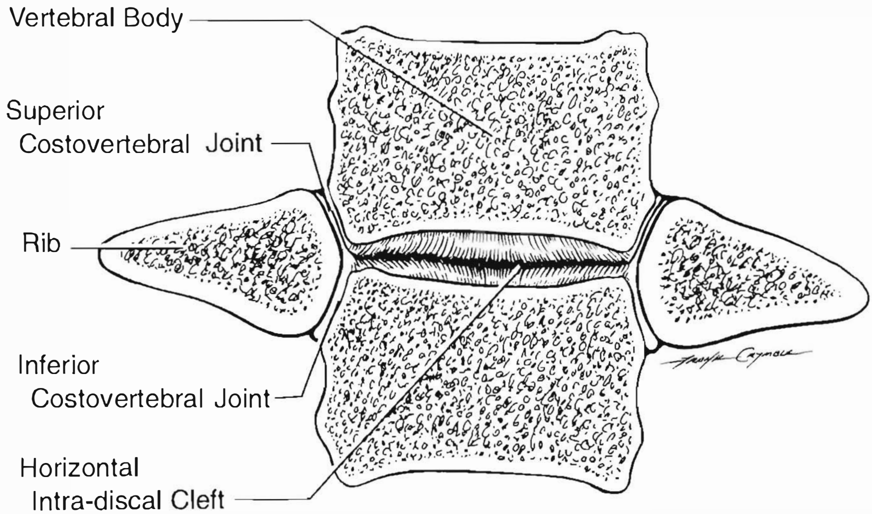


Figure 168.
Anatomy of the lateral shift lesion. It is proposed that a horizontal cleft occurs through the posterior 1/3 of the intervertebral disc confluent with the superior costovertebral joints bilaterally allowing the superior vertebra to sublux laterally.

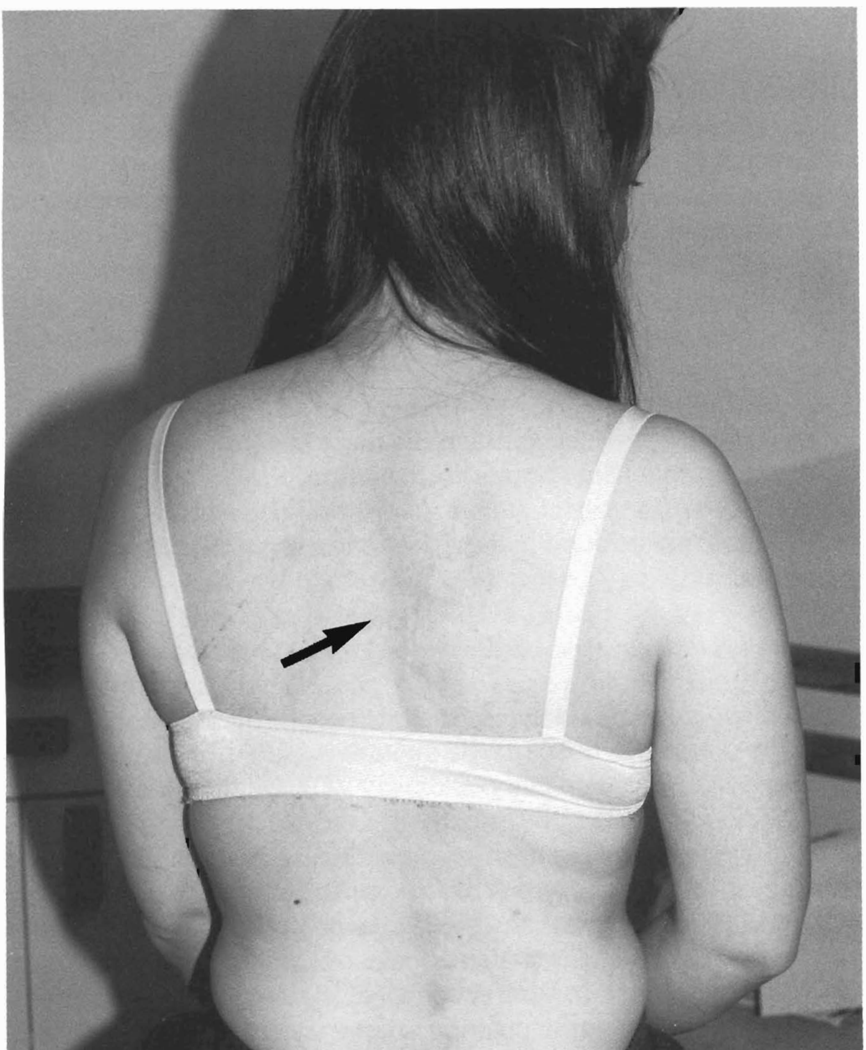


Figure 169.
This patient sustained a left lateral shift of T5 and the left and right sixth ribs in a motor vehicle accident one month prior. Note the complete block of right rotation at the subluxed segment.

Figure 170.
Mobilization technique for a left lateral shift of the sixth ring. Strong distraction must be maintained throughout the technique.

T6 is right rotated in hyperflexion, neutral and extension, the right sixth rib is anteromedial posteriorly and the left sixth rib is posterolateral posteriorly. All active movements produce a 'kink' at the level of the subluxation, the worst movement is often rotation (Fig. 169). The passive tests of arthrokinematic function of the zygapophyseal and costotransverse joints are reduced but present. The right mediolateral translation mobility test is completely blocked.

Prior to reduction of the subluxation the arthrokinetic tests for stability are normal. Subsequent to reduction, the arthrokinetic tests of anteroposterior costal stability are normal, the right rotational test of T5-T6 is positive and there is excessive left lateral translation of the ring.

Mobilization technique for a left lateral shift of the sixth ring (Fig. 170)

The patient is in left sidelying, the head supported on a pillow and the arms crossed to the opposite shoulders. With the left hand, the right seventh rib is palpated posteriorly with the thumb and the left seventh rib is palpated posteriorly with the index or long finger. T6 is fixed by compressing the two seventh ribs towards the midline. Care must be taken to avoid fixation of the sixth ribs which must be free to glide relative to the transverse processes of T6. The other hand/arm lies across the patient's crossed arms to control the thorax. Segmental localization is achieved by flexing and extending the joint until a neutral position of the zygapophyseal joints is achieved. This localization is maintained as the patient is rolled supine *only until contact is made between the table and the dorsal hand.*

From this position, T5 and the left and right sixth ribs are translated laterally to the right through the thorax to the motion barrier. Strong longitudinal distraction is applied through the thorax prior to the application of a high velocity, low amplitude thrust. The thrust is in a lateral direction in the transverse plane. The goal of the technique is to laterally translate T5 and the left and right sixth ribs relative to T6.

Following reduction of the subluxation, the arthrokinetic tests for mediolateral translation will reveal the underlying instability of the ring. Stabilization is then required.

STABILIZATION THERAPY

In addition to major trauma to the thorax, cumulative microtrauma can lead to postural changes, altered movement patterns and associated functional instability. Stabilization therapy is a concept which considers the integrated relationship between the legs, pelvic girdle, trunk and upper extremity. The central feature of this concept is that the trunk muscles must hold the vertebral column stable in order that independent upper and lower extremity movement may occur and also that load may be transferred from the upper extremity to the ground[25].

Essentially, the patient is taught to specifically recruit the trunk muscles isometrically and then to maintain this brace as they move the upper and lower extremities independently. Initially, the base of support is very stable. The program is progressed by increasing the degree of difficulty by reducing the base of support, by making the base more unstable and/or by increasing the load which must be controlled. The program is directed by the patient's needs and is limited only by the therapist's imagination. The use of gymnastic balls, rolls, balance boards and pulleys can make stabilization therapy cost effective, fun and still very challenging. Figures 171 to 191 illustrate some of the exercises used in stabilization therapy. The reader is referred to Irion[26] and Saal[27] for further ideas on stabilization training which involves the total musculoskeletal system.

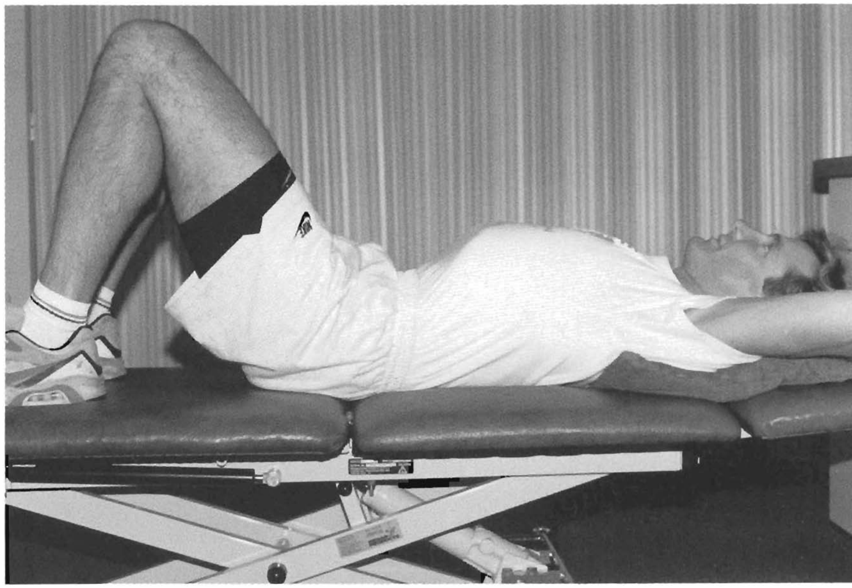


Figure 171.
Trunk bracing - level 1. The patient is taught to co-contract the anterior and posterior trunk muscles isometrically without excessive posterior pelvic tilting. When done correctly the lower costal margin should be level with the pelvic girdle unlike the model in this illustration who is posteriorly tilting his pelvic girdle too much. A pressure biofeedback unit or a blood pressure cuff placed in the lumbar region can be a useful tool for education. Proper co-contraction of the trunk muscles will elevate the pressure in the cuff 10 to 15 points on the pressure gauge.

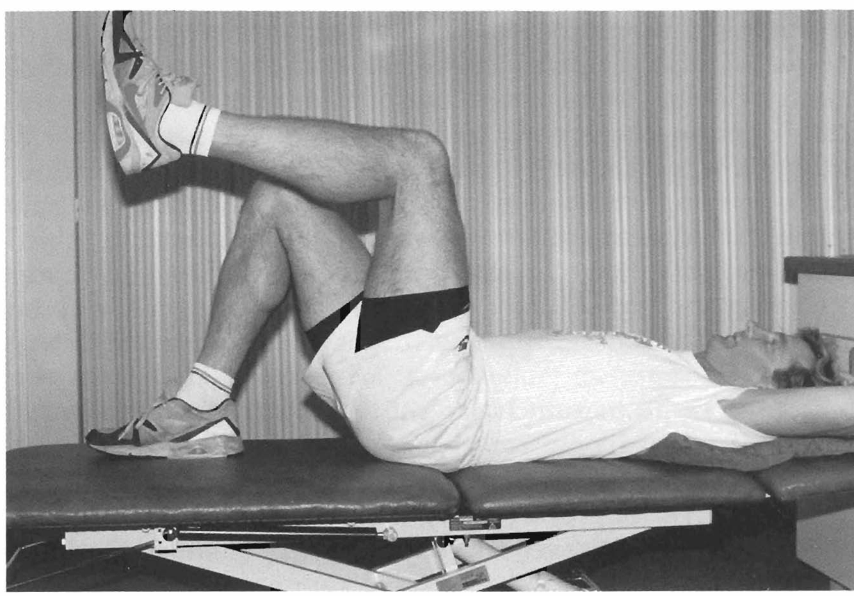


Figure 172.
Trunk bracing - level 2. The patient is instructed to maintain the co-contraction as in level 1 and to flex the hip and knee to 90 degrees. The pressure gauge should remain at the same level if the co-contraction is maintained properly.

NORMAL MOBILITY WITH PAIN

Patients presenting with pain in the thorax without objective mechanical findings can be a challenge to treat. Given the nature of visceral referral of pain to the thorax, a team approach to the problem is best. If all medical conditions are ruled out and there is no specific articular, muscular, neural or dural mobility dysfunction to be found then a postural approach following the principles

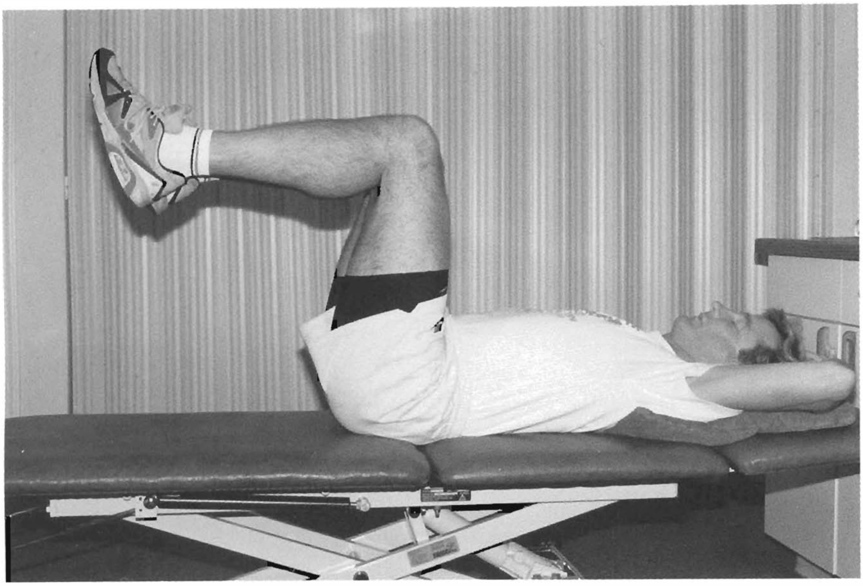


Figure 173.
Trunk bracing - level 3. From the starting position of level 2, the patient is instructed to maintain the co-contraction of the trunk and to bring the opposite hip and knee to 90 degrees without losing trunk control.

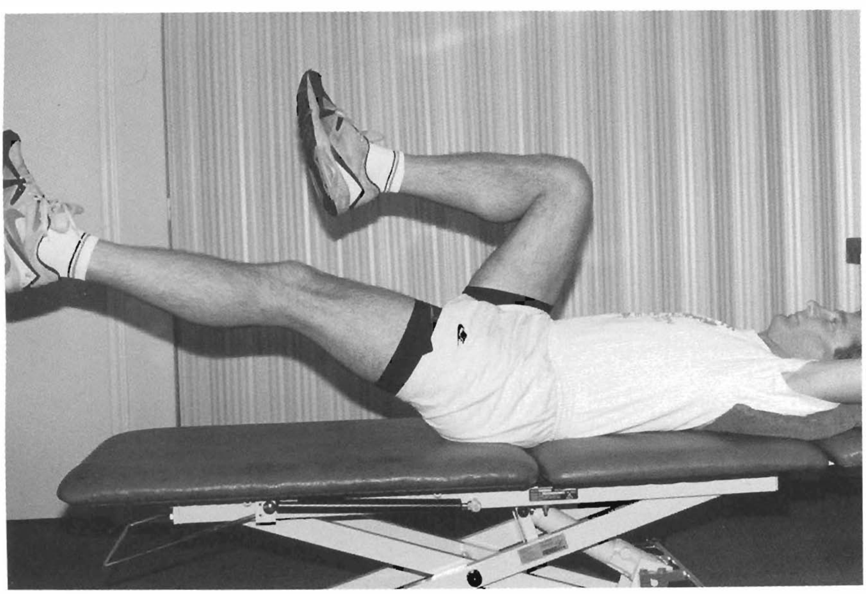


Figure 174.
Trunk bracing - level 4. From the starting position of level 3, the patient is instructed to maintain the co-contraction of the trunk and slowly extend one leg without losing trunk control.

of stabilization therapy can be tried. Repetitive overuse of the articular and myofascial tissue will respond to the appropriate correction of resting and working postures together with an exercise program aimed at balancing the trunk musculature and restoring optimal movement patterns. Diligence and commitment on the part of the patient and therapist is required to achieve successful rehabilitation.

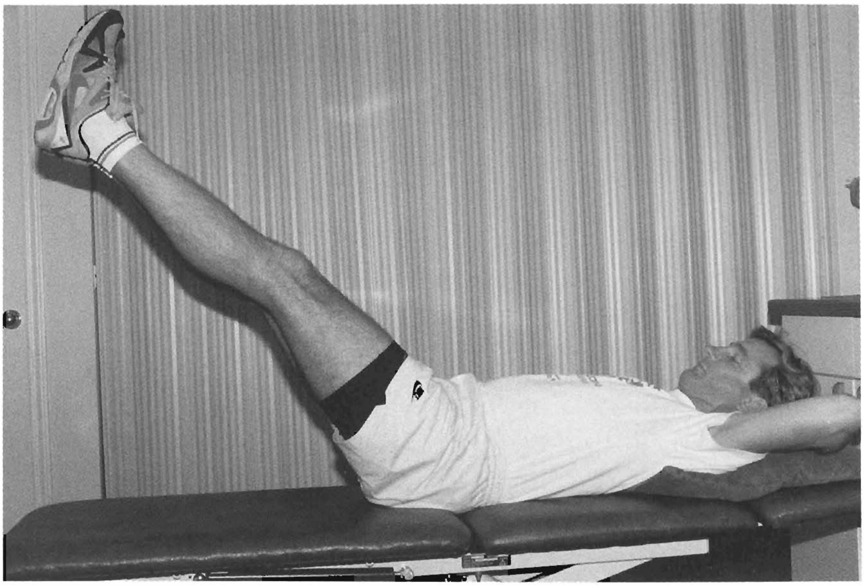


Figure 175.

Trunk bracing - level 5. From the starting position of level 4, the patient is instructed to maintain the co-contraction of the trunk and slowly extend both legs without losing trunk control.

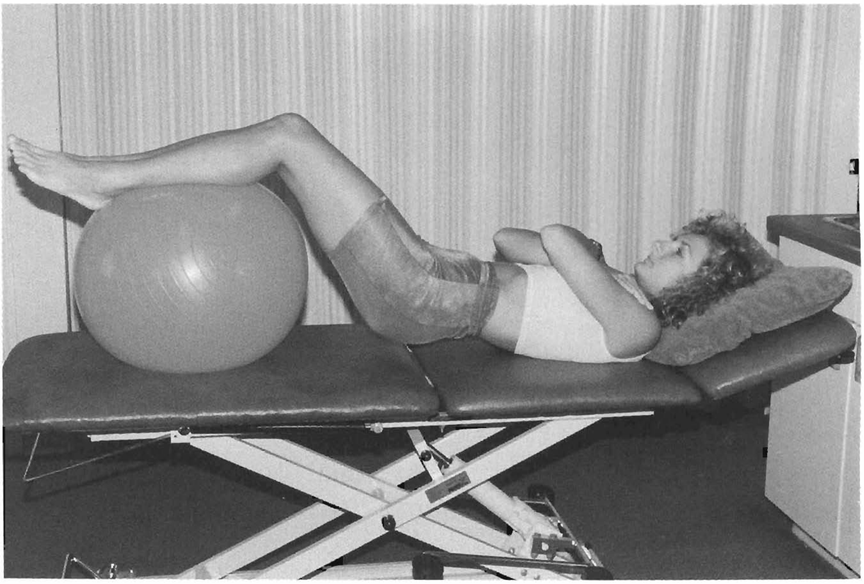


Figure 176.

Trunk control with an unstable base. The patient is instructed to co-contract the trunk, tighten the buttocks (recruit the gluteus maximus), press the inner thighs together (recruit the adductors if there is an unstable pubic symphysis) and then to use the hamstrings to lift the trunk off of the table. The lift should occur at the scapular level and not through the unstable segment. This exercise is progressed by increasing the height of the elevation. Once full lift is achieved, the patient is instructed to roll the ball from side to side with control.

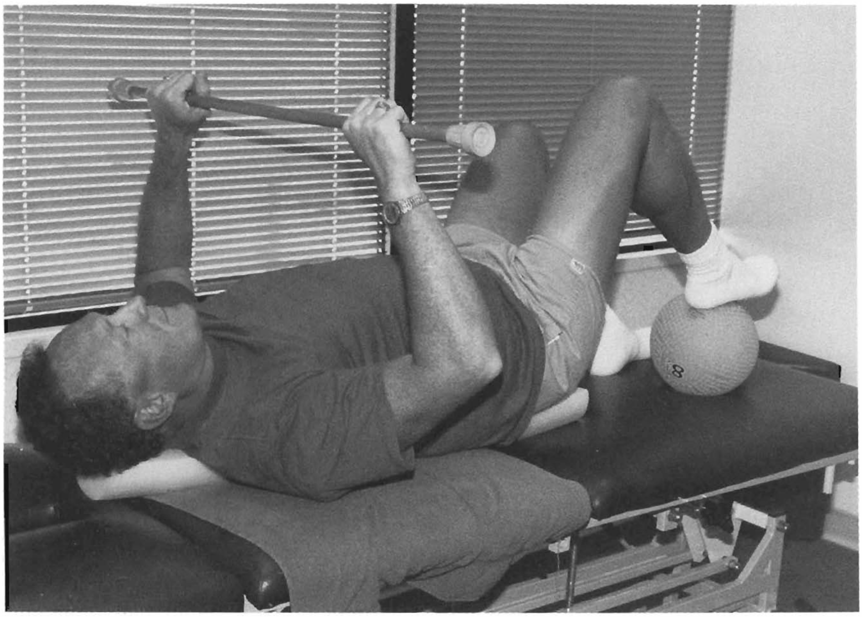


Figure 177.

Trunk control with an unstable base. If the patient is unable to lift the trunk without reproducing symptoms the base may be altered by placing the patient on a 1/2 roll. With the trunk braced, a variety of exercises may be performed such as unilateral or bilateral elevation of the arms, unilateral or bilateral elevation of the feet or rolling a ball with one or two feet. The therapist can increase the challenge by applying resistance to the stick held between the patient's hands. The direction of the resistance is dictated by the patient's needs.

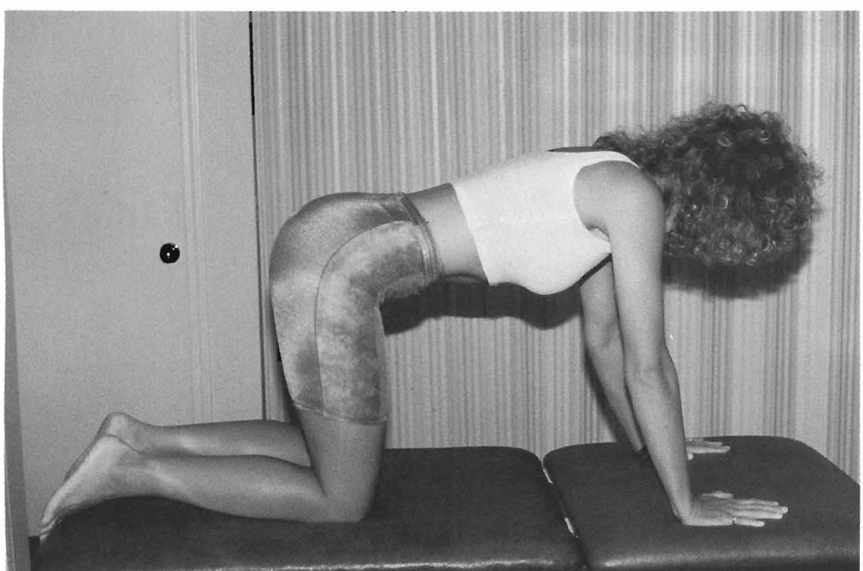


Figure 178.

Trunk control in four point kneeling. Proprioception from the supporting surface is decreased thus increasing the difficulty of the exercise. The patient is instructed to find their neutral thoracolumbar position.

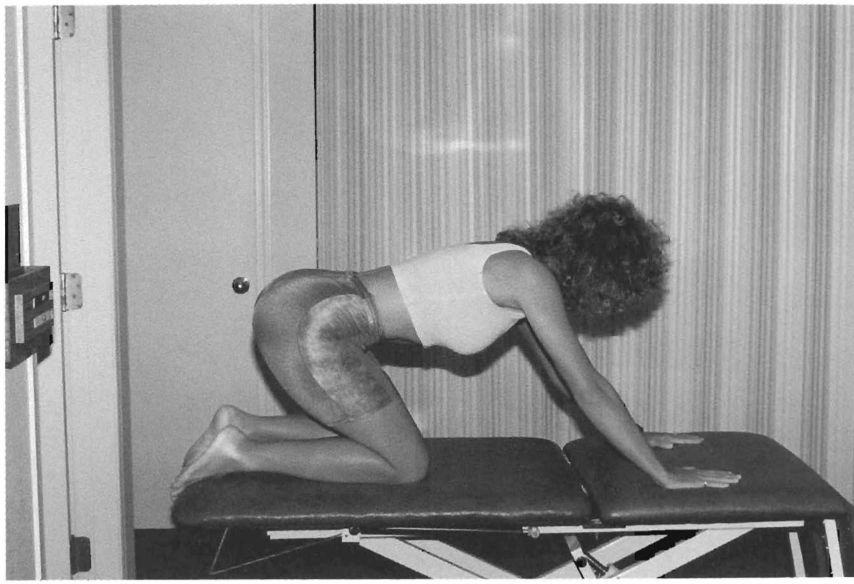


Figure 179.
Trunk control in four point kneeling. The patient is instructed to maintain their neutral trunk position and to sit back without flexing or 'breaking' through their unstable region.

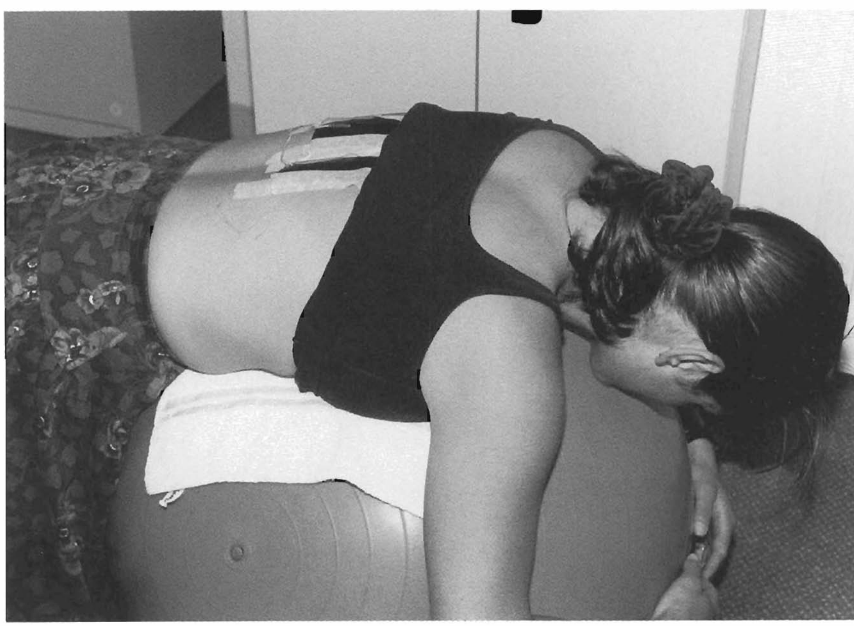


Figure 180.
Re-education of the segmental neutral position. An unstable segment often remains kyphosed when the rest of the vertebral column extends. Specific extension exercises over a ball (rolling forward and backward) together with a 50 Hz muscle stimulating current over the involved segment can help to restore the appropriate motion.

Figure 181.

Trunk control with independent arm movement. A progression to the above exercise is to instruct the patient to unilaterally abduct or elevate one arm while maintaining a stable trunk.

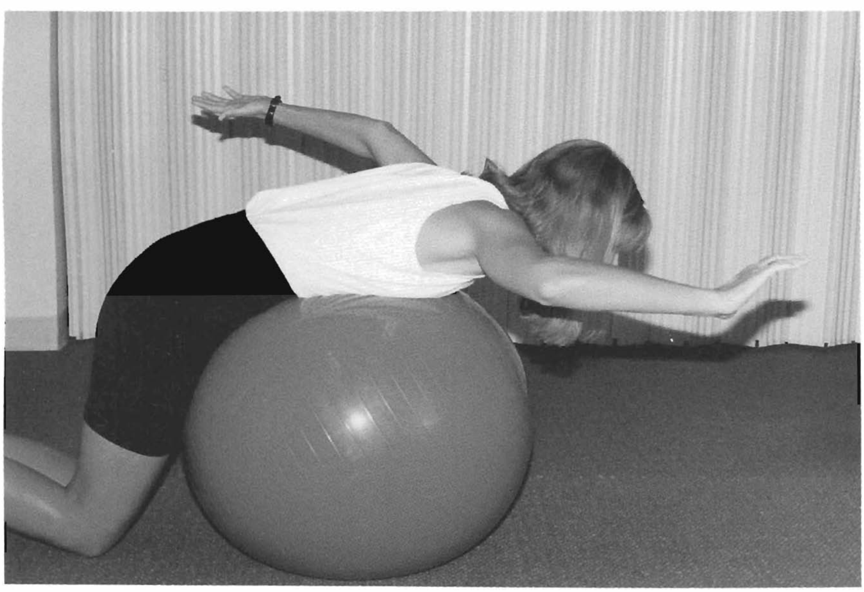


Figure 182.

Trunk control with independent arm movement. A further progression to the above exercise is to instruct the patient to lift one arm forward, the other arm backward and to specifically extend the trunk as they roll forward on the ball. The arm position is then reversed as they roll back.

Figure 183.

Taping for proprioceptive input. When the segmental myofascia is unable to control excessive angular or linear motion, tape can be a useful temporary reminder as to which movements the patient should avoid. Flexion and rotation can be controlled but not prevented by applying tape obliquely across the unstable region.

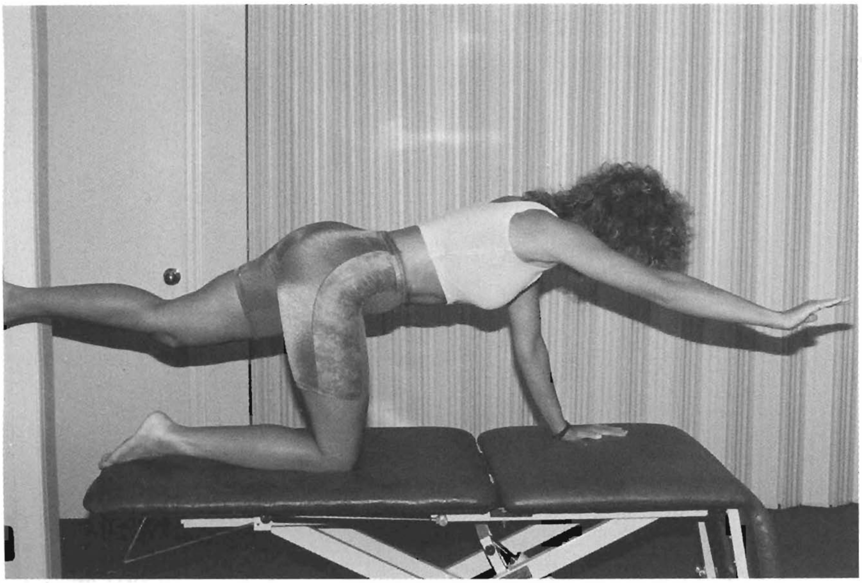


Figure 184.

Trunk control with independent arm and leg movement. The patient is instructed to maintain their neutral trunk position and to unilaterally elevate one arm and extend the opposite leg.

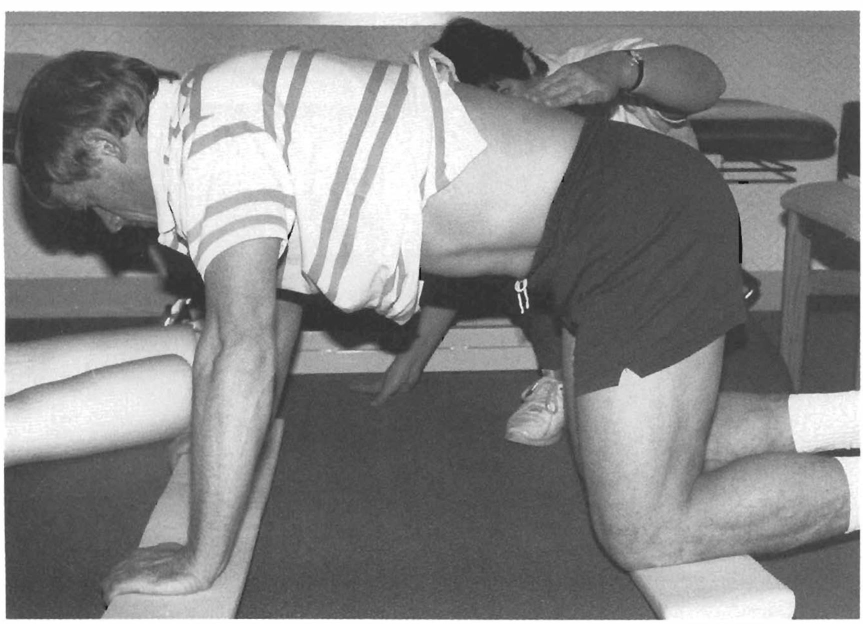


Figure 185.

Trunk control with independent arm and leg movement on an unstable base. The difficulty of the above exercise can be increased by decreasing the base of support with two 1/2 rolls.

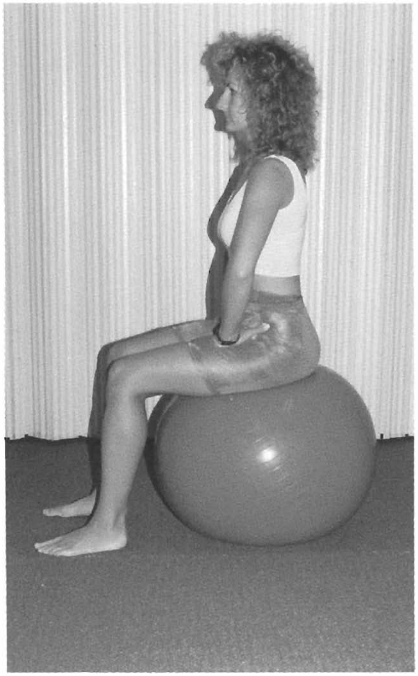


Figure 186.

Trunk control - sitting. The patient is taught to achieve a neutral trunk position while sitting on a ball. The exercise is progressed by having them move the ball backwards, forwards and sideways while maintaining trunk control.

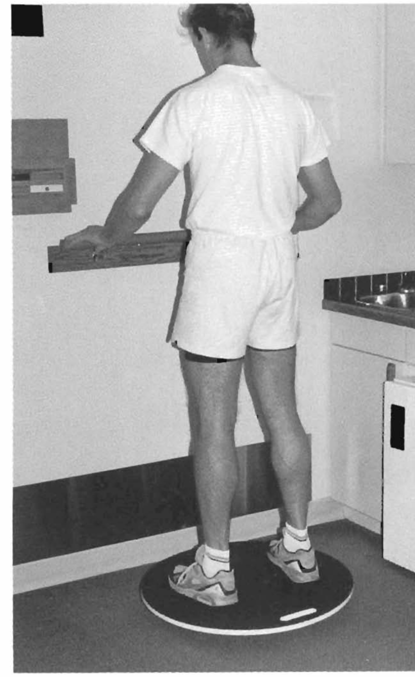


Figure 188.

Trunk control - standing. The patient is instructed to co-contract the trunk and to move the body weight forwards, backwards, sideways and around while standing on a wobble board.

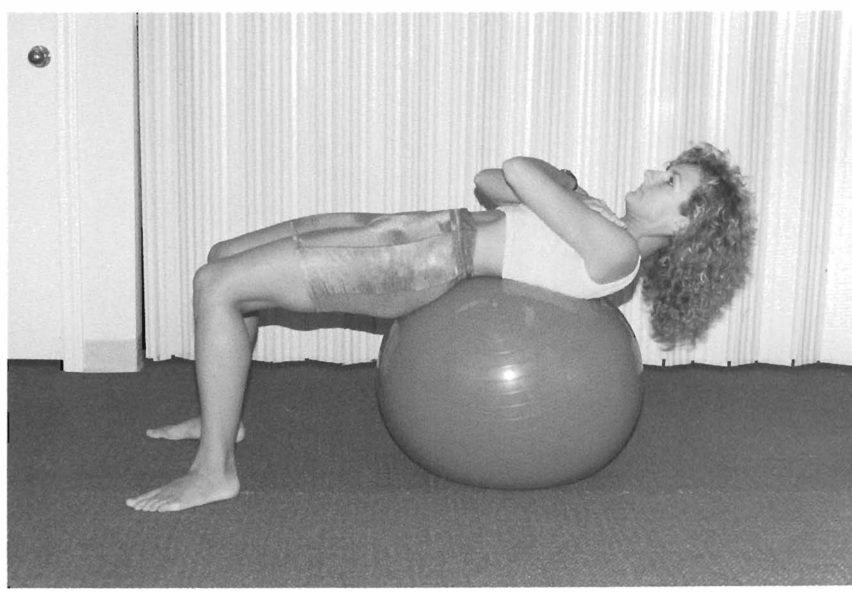
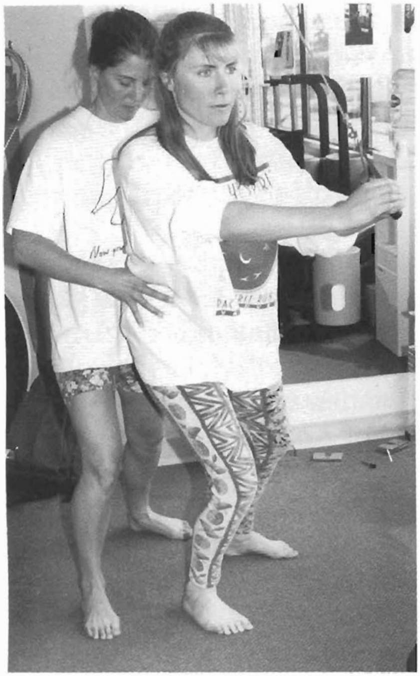


Figure 187.

Trunk control - sitting. The exercise is progressed by having the patient slowly lower the controlled trunk into a supine supported position from the seated position. Care is taken to ensure that the unstable segment does not flex or translate during this exercise.



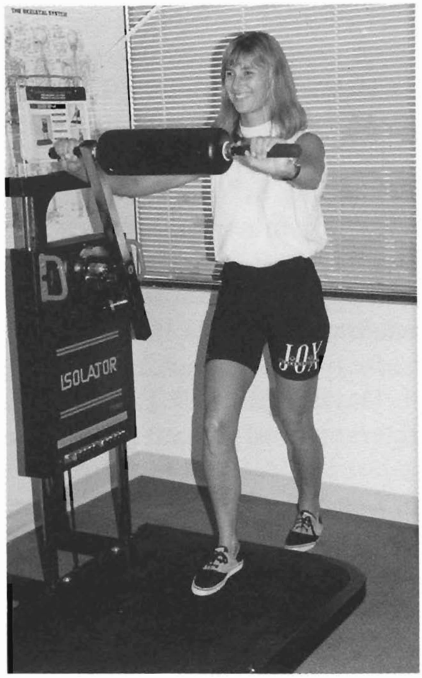


Figure 189.

Trunk control - standing and rotating. The patient is instructed to co-contract the trunk and to move the body through rotation by turning around the weight bearing femur. This exercise requires control of the trunk and the hip rotators. Resistance may be added through pulleys or resistive tubing.

Figure 190.

Trunk control - standing and pushing/pulling. The patient is instructed to co-contract the trunk and to push/pull a load by using the lower extremities. Care is taken to ensure that the unstable segment does not flex or translate during this exercise.

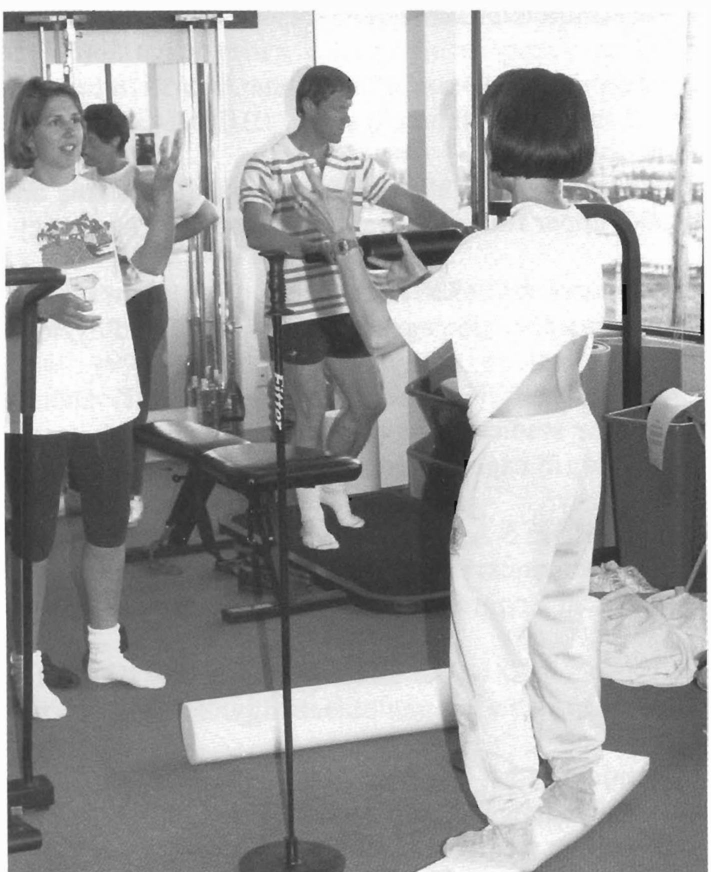


Figure 191.

Trunk control - standing. The patient is instructed to stand on a 1/2 roll, to co-contract the trunk and then to unilaterally and bilaterally elevate their arms. The exercise can be progressed by tossing a ball to the patient varying the speed and the direction of the throw.

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