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The Posterior Layer of the Thoracolumbar Fascia

Its Function in Load Transfer From Spine to Legs

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Study Design. The superficial and deep lamina of the posterior layer of the thoracolumbar fascia have been studied anatomically and biomechanically. In embalmed human specimens, the posterior layer has been loaded by simulating the action of various muscles. The effect has been studied using raster photography.

Objectives. To study the role of the posterior layer of the thoracolumbar fascia in load transfer between spine, pelvis, legs, and arms.

Summary of Background Data. It has been determined whether muscles such as the gluteus maximus, latissimus dorsi, erector muscle, and biceps femoris are functionally coupled via the thoracolumbar fascia. The caudal relations of the posterior layer of the thoracolumbar fascia have not been previously studied.

Methods. Dissection was directed to the bilaminar posterior layer of the thoracolumbar fascia of 10 human specimens. The superficial and deep lamina were studied using visual inspection and raster photography. Tension to the posterior layer of the fascia was simulated by traction to various muscles and measured by studying the displacement in the posterior layer.

Results. Traction to a variety of muscles caused displacement of the posterior layer. This implies that *in vivo*, the superficial lamina will be tensed by contraction of various muscles, such as the latissimus dorsi, gluteus maximus and erector muscle, and the deep lamina by contraction of the biceps femoris. Caudal to the level of L4 (in some specimens, L2–L3), tension in the posterior layer was transmitted to the contralateral side.

Conclusions. Anatomic structures normally described as hip, pelvic, and leg muscles interact with so-called arm and spinal muscles via the thoracolumbar fascia. This allows for effective load transfer between spine, pelvis, legs, and arms—an integrated system. Specific electromyographic studies should reveal whether the gluteus maximus muscle and contralateral latissimus dorsi muscle are functionally coupled, especially during rotation of the trunk. In that case, the combined action of these muscles assists in rotating the trunk, while simultaneously stabilizing the lower lumbar spine and sacroiliac joints. [Key words: low back pain, lumbar spine, sacroiliac joint, spinal stability, thoracolumbar fascia] **Spine 1995;20:753–758**

To understand and treat low back pain, models are generally used based on descriptive anatomy. This branch of anatomy was developed to determine the structures our body consists of, and to categorize them. Categories such as spine, pelvis, and legs are primarily based on bone anatomy.

Functional anatomy of the locomotor system, which is strongly linked to biomechanics, attempts to explain how bones, ligaments, and muscles operate as a system. Consequently, use of categories such as spine and pelvis can be misleading. From a biomechanical and neurophysiologic point of view, they are fully integrated. "Back muscles," for instance, are categorized in descriptive anatomy as typically spinal. However, parts of these "back muscles" bridge the sacroiliac (SI) joints. For example, in humans, the multifidus muscle shows an extensive attachment to both the sacrum and the iliac crest.[6]

Using descriptive anatomic models, it is tempting to regard pain in the area of the SI joints as a separate syndrome, not as part of low back pain. However, these joints are fully integrated in the spine-pelvis-leg mechanism.[8] To function properly, this mechanism needs stability over the pelvis and the SI joints. Effective load transfer across the SI joints requires specific action of a variety of muscles, leading to sufficient compression of the SI joint and preventing shear.[8,9] In enlarging compression, the biceps femoris and gluteus maximus muscles are important.[3,7,12,13,16–18] Both muscles are attached to the sacrotuberous ligament, which functionally bridges the SI joint. Obviously, pain in the area of the SI joints is not necessarily a local problem. It can be symptomatic of a failed load transfer system.[8,9]

The strong thoracolumbar fascia can be used for load transfer.[9] The posterior layer of this fascia is of special

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interest because of its multiple connections. The main interest is whether muscle-induced tension of this fascia can assist in transferring load between spine, pelvis, legs, and arms.

Methods

Dissection was directed to the posterior layer of the thoracolumbar fascia of 10 human specimens (six male, four female; ages between 65 and 90 years). Specimens were embalmed by vascular perfusion with a medium containing 2.2% formaldehyde. The posterior layer of the thoracolumbar fascia was studied by visual inspection. For documentation, raster photography was used on three specimens (one female, two male) using a raster of 1.20 × 1.60 m with numbered windows (10 × 10 cm wide), fixed at a distance of 20 cm from the thoracolumbar fascia. By magnifying the photos of the individual windows, the orientation of the fibers could be described in detail.

Tension to the muscles attached to the superficial lamina of the posterior layer of the thoracolumbar fascia was simulated by traction, using adjustable traction power units (Eltrac 471-1471.905; Enraf Nonius, Delft, The Netherlands). A force of 50 N was used, applied to the muscle and its fascia by means of an adapted forceps, pulling in the direction of the muscle fibers. The forceps was rigidly fixed to that part of the muscle and its fascia located nearest to the superficial lamina (Figure 1). In a custom-made frame, traction was applied with the power units to the following muscles: latissimus dorsi (at the level of T11 and L3–L4), gluteus maximus and medius, external oblique, and trapezius. The effect of the traction was estimated by measuring the distance between the attachment site of the forceps and the most remote displacement of the superficial lamina. The displacement of markers attached to the posterior layer was measured using raster photography.

Subsequently, the superficial and deep lamina of the posterior layer were separated with a blunt forceps cautiously inserted into the loose connective tissue between the laminae. The forceps was carefully moved from the midline laterally and caudally up to the site where the fibers of the superficial lamina fuse with the fascia of the latissimus dorsi. Dissection was necessary to separate the more caudal parts of the superficial and deep lamina, generally starting at the level of L5. Special attention was given to the connections with the sacrotuberous ligament. Traction (50 N) was applied to the tendon of the long head of the biceps femoris (directed to either lateral or medial) and to the muscle and its fascia of the serratus posterior inferior and the internal oblique muscles. The effect of tension on the deep lamina was studied as described for the superficial lamina.

Results

Anatomy

In all preparations, the posterior layer of the thoracolumbar fascia covers the back muscles from the sacral region through the thoracic region as far as the fascia nuchae. At the levels of L4–L5 and the sacrum, strong connections exist between the superficial and deep lamina. The transverse abdominal and internal oblique muscles are indirectly attached to the thoracolumbar fascia through a dense raphe formed by fusion of the middle layer[1] of the thoracolumbar fascia and both laminae of the posterior layer. This "lateral raphe"[1,2] is localized lateral to the erector spinae and cranial to the iliac crest.

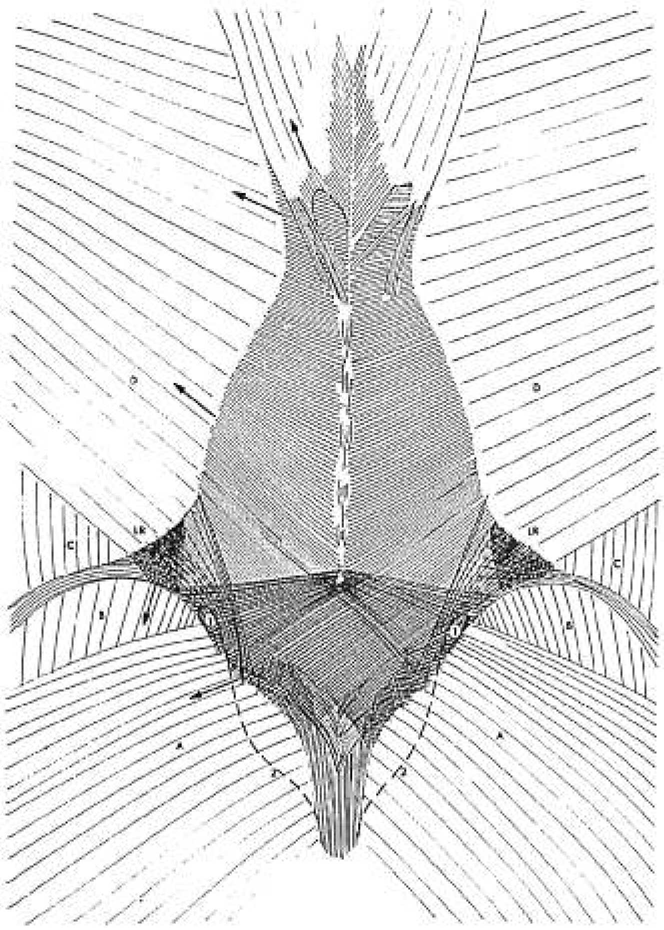

Figure 1. The superficial lamina. A. Fascia of the gluteus maximus. B. Fascia of the gluteus medius. C. Fascia of external oblique. D. Fascia of latissimus dorsi. Note the cross-hatched appearance of the superficial lamina over the sacrum due to different fiber directions of latissimus dorsi and gluteus maximus. 1. Posterior superior iliac spine. 2. Sacral crest. LR. Part of lateral raphe. Arrows (at left) indicate, from cranial to caudal, the site and direction of the traction (50 N) given to trapezius, cranial and caudal part of the latissimus dorsi, gluteus medius, and gluteus maximus, respectively.

Superficial Lamina. The superficial lamina of the posterior layer of the thoracolumbar fascia is continuous with the latissimus dorsi, gluteus maximus, and partly the external oblique muscle of the abdomen and the trapezius muscle. Cranial to the iliac crest, the lateral border of the superficial lamina is marked by its junction with the latissimus dorsi muscle.

The fibers of the superficial lamina are orientated from craniolateral to caudomedial. Only a few fibers of the superficial lamina are continuous with the aponeurosis of the external oblique and the trapezius. Most of the fibers of the superficial lamina derive from the aponeurosis of the latissimus dorsi and attach to the supraspinal ligaments and spinous processus cranial to L4. Caudal to L4–L5, the superficial lamina is generally loosely (or not at all) attached to midline structures such as supraspinal ligaments, spinous processes, and median sacral crest. In fact, they cross to the contralateral side, where they attach to the sacrum, posterior superior iliac spines, and iliac crest. The level at which this phenomenon occurs varies. It is generally caudal to L4 but in some preparations it is already at L2–L3.

At sacral levels, the superficial lamina is continuous with the fascia of the gluteus maximus. These fibers are orientated from craniomedial to caudolateral. Most of these fibers attach to the median sacral crest. However, at the level of L4–L5, and in some specimens as caudal as S1–S2, fibers partly or completely cross the midline, attaching to the contralateral posterior superior iliac spine and iliac crest. Some of these fibers fuse with the lateral raphe and with fibers derived from the fascia of the latissimus dorsi. Because of the different fiber directions of the latissimus dorsi and the gluteus maximus, the superficial lamina has a cross-hatched appearance at L4–L5, and in some preparations also at L5–S2.

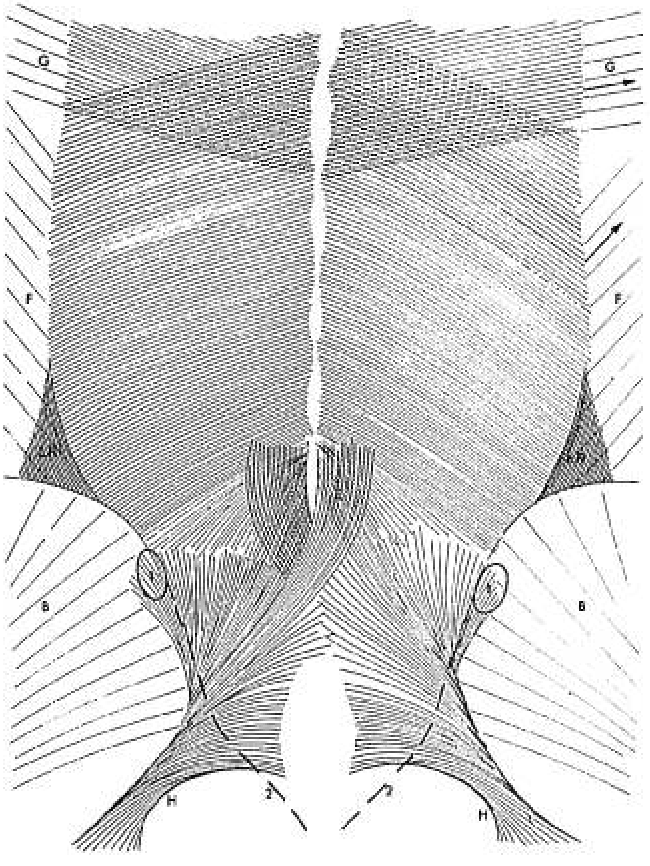

Figure 2. The deep lamina. B. Fascia of the gluteus medius. E. Connections between the deep lamina and the fascia of the erector spinae. F. Fascia of the internal oblique. G. Fascia of the serratus posterior inferior. H. Sacrotuberous ligament. 1. The posterior superior iliac spine. 2. Sacral crest. LR. Part of lateral raphe. Arrows (at right) indicate, from cranial to caudal, traction to serratus posterior inferior and internal oblique, respectively.

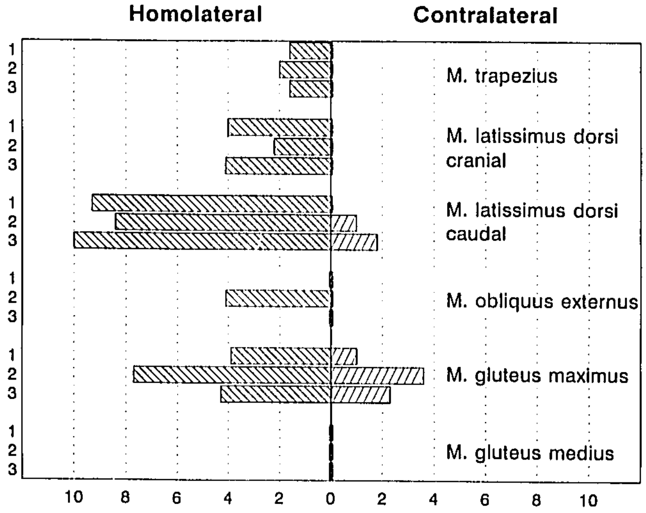

Figure 3. The effect on the superficial lamina of traction to the aponeurosis and muscle fibers of different muscles. Data reflect the distance (in cm) between site of traction and most distant visual displacement of fibers of the homolateral and contralateral superficial lamina, in three preparations (1, 2, and 3).

Deep Lamina. At lower lumbar and sacral levels, the fibers of the deep lamina are oriented from craniomedial to caudolateral (Figure 2). At sacral levels, these fibers are fused with those of the superficial lamina. Because fibers of the deep lamina are continuous with the sacrotuberous ligament, an indirect link exists between this ligament and the superficial lamina. There also is a direct connection with some fibers of the deep lamina.

In the pelvic region, the deep lamina is connected to the posterior superior iliac spines, iliac crests, and the long posterior sacroiliac ligament.[11] This ligament originates from the sacrum and attaches to the posterior superior iliac spines.

In the lumbar region, fibers of the deep lamina derive from the interspinous ligaments. They attach to the iliac crest and more cranially to the lateral raphe, to which the internal oblique is attached. In some specimens, fibers of the deep lamina cross to the contralateral side between L5–S1. In the depression between the median sacral crest and the posterior superior and inferior iliac spines, fibers of the deep lamina fuse with the fascia of the erector. More cranially, in the lumbar region, the deep lamina becomes thinner and freely mobile over the back muscles. In the lower thoracic region, fibers of the serratus posterior inferior muscle and its fascia fuse with fibers of the deep lamina.

Kinematics

Traction to the Superficial Lamina. Depending on the site of the traction, quite different results were obtained (Figure 3). Traction to the cranial fascia and muscle fibers of the latissimus dorsi muscle showed limited displacement of the superficial lamina (homolaterally up to 2–4 cm). Traction to the caudal part of the latissimus dorsi caused displacement up to the midline. This midline area is 8–10 cm removed from the site of traction. Between L4–L5 and S1–S2, displacement of the superficial lamina occurred even contralaterally. Also, traction to the gluteus maximus caused displacement up to the contralateral side. The distance between the site of traction and visible displacement varied from 4 to 7 cm. In Figure 3, the contralateral effect of traction to the caudal part of the latissimus dorsi is small compared with the gluteus maximus, although the ipsilateral effect is larger. This is expected because of the relatively large distance between the impact side on the latissimus dorsi and the midline, compared with that of the gluteus maximus. The effect of traction to the external oblique varied markedly between the different preparations. In all preparations, traction to the trapezius muscle resulted in a relatively small effect (up to 2 cm). There was no effect seen of traction to the medial gluteal muscles.

Traction to the Deep Lamina. Traction to the biceps tendon, applied in the lateral direction, resulted in displacement of the deep lamina up to the level L5–S1. Obviously, this load transfer is conducted by the sacrotuberous ligament.[13,16] In two specimens, displacement occurred at the contralateral side, 1–2 cm away from the midline. Traction to the biceps tendon directed medially showed homolateral displacement in the deep lamina, up to the median sacral crest. Traction to the internal oblique did not result in visible displacement. In two specimens, fibers of the deep lamina were damaged by the traction to the serratus posterior inferior muscle, whereas in one specimen, displacement was visible up to 3.5 cm away from the site of traction.

■ Discussion

The present study confirms some previous studies and disagrees with others. The bilaminar structure of the posterior layer of the thoracolumbar fascia has been described by several authors.[1,2,4–6] Bogduk, Macintosh, and Twomey[1,2] described the orientation of the fibers of the superficial and deep lamina as, respectively, caudomedial and caudolateral. The present study confirmed the orientation of the laminae and their attachments. According to most studies,[1,2,4] the latissimus dorsi is mentioned as the significant structure from which fibers of the superficial lamina originate. The gluteus maximus as the origin for formation of the superficial fascia is ignored. Bogduk and Macintosh[1] stated that fibers located caudally from L3 decussate to the contralateral site, although it was not possible to trace the precise origin of these fibers because of strong fusion to midline structures. The present study confirmed the phenomenon of crossing fibers. The level of the crossing varies from L2–S2. In contrast to the study of Bogduk and Macintosh,[1] no connections were found between the serratus posterior inferior and the superficial lamina: Its fascia was exclusively connected to the deep lamina.

Bogduk, Macintosch, and Twomey[1,2] described the deep lamina as a structure consisting of bands of collagen fibers extending from the lumbar spinal processes to the iliac crest and lateral raphe. However, we cannot confirm the existence of bands of collagen fibers; we find a continuous layer. Those authors paid no attention to the sacral part of the deep lamina. As a result, the connections with the sacrotuberous ligaments were omitted. Therefore, the biomechanical model, as proposed by Bogduk and Twomey,[2] is incomplete. The bracing effect of the thoracolumbar fascia on the lower lumbar spine and SI joints, essential for proper load transfer between spine and legs,[8,9] can be adequately described only if the caudal part of the thoracolumbar fascia is included.

As shown by the traction tests, the tension of the posterior layer of the thoracolumbar fascia can be influenced by contraction or stretching of a variety of muscles. In our experience, the effect of traction in embalmed human bodies is smaller than that in unembalmed bodies. Furthermore, specimens of relatively high age were used. The effects measured in this study probably would be larger in young, healthy individuals. It is noteworthy that muscles, especially those like the latissimus dorsi and gluteus maximus, are able to exert a contralateral effect. This implies that both the gluteus maximus muscle and contralateral latissimus dorsi muscle tense the posterior layer. Hence, parts of these muscles provide a pathway for uninterrupted mechanical transmission between pelvis and trunk. It could be argued that the lack of connection between the superficial lamina of the posterior layer and the supraspinous ligaments in the lumbar region is a disadvantage for stability. However, it would be disadvantageous only if strength, coordination, and effective coupling of the gluteus maximus and the caudal part of the contralateral latissimus dorsi were diminished. We assume that the strength increase of the mentioned muscles accomplished by specific or torsional trunk training can influence the quality of the posterior layer. In this concept, the posterior layer of the thoracolumbar fascia plays an integrating role in rotation of the trunk and in load transfer, and thus stability of the lower lumbar spine and pelvis.

Recently, a biomechanical model of the SI joints was proposed.[8,9] It was stated that joints with predominantly flat surfaces are well suited for transferring large moments of force, but are vulnerable to forces in the plane of the joint surfaces.[8,9] Therefore, flat joint surfaces go with restricted joint excursions. In a model[12] of the SI joints based on anatomic and biomechanical findings, the principle of form and force closure was discussed. Form closure refers to a stable situation with closely fitting joint surfaces, where no extra forces are needed to maintain the state of the system, given the actual load situation. In this situation, no lateral forces are needed to counterbalance the effects of the vertical load. With force closure, a lateral force is needed.

The SI joint, with its undulated form and symmetrical ridges and depressions, combined with compression and the generated friction, is an example of a joint remaining stable through a combination of form and force closure.[14] If force closure is not sufficient—*e.g.*, due to insufficient muscle action and hence insufficient ligament strain—form closure becomes important.

Pelvic instability (and peripartum pain) can be relieved by applying a pelvic belt, a device that self-braces the SI joints.[10,15] Force closure is increased by such a belt, located just cranially to the greater trochanter and caudally to the SI joints.[8,15] The belt can be used with small force, resembling the action of laces of a shoe. By exerting compression on the lower lumbar spine and pelvis, the posterior layer of the thoracolumbar fascia can accomplish force closure physiologically. The present study showed that the coupled function of gluteus maximus and contralateral latissimus dorsi creates a force perpendicular to the SI joints.

Finally, there is a possible role of the erector muscle in load transfer. Between the lateral raphe and the interspinous ligament, the deep lamina encloses the erector muscle. Here, contraction of the erector muscle will longitudinally increase the tension in the deep lamina directly by pulling and indirectly by dilating the complete posterior layer of the thoracolumbar fascia. Consequently, it can be assumed that training of muscles like the gluteus maximus, latissimus dorsi, and erector can help increase force closure by strengthening the posterior layer of the thoracolumbar fascia.

■ Conclusion

In transferring forces between spine, pelvis, and legs, the posterior layer of the thoracolumbar fascia may play an important role, especially in rotation of the trunk and stabilization of the lower lumbar spine and SI joints. The gluteus maximus and the latissimus dorsi merit special attention because they can conduct forces contralaterally, via the posterior layer. The effect of contraction, especially of the latissimus dorsi, will be large because forces derived from its caudal part are fully transferred to the thoracolumbar fascia.

The design of training methods to relieve low back pain requires knowledge of the functional anatomy of the thoracolumbar fascia and of its role in load transfer. Further studies must reveal whether muscles like the gluteus maximus and the caudal part of the latissimus dorsi need to be emphasized in training programs. Because of the coupling between gluteus maximus and contralateral latissimus dorsi muscle via the posterior layer of the thoracolumbar fascia, caution is needed in categorizing structure as belonging exclusively to arms, spine, or legs.

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