# ON THE DISTRIBUTION OF PAIN ARISING FROM DEEP SOMATIC STRUCTURES WITH CHARTS OF SEGMENTAL PAIN AREAS.*

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### *Pain from interspinous ligaments.*

In a recent paper (4) I was able to show that pain produced experimentally from muscle is always felt diffusely, and is referred upon a spinal segmental pattern. Further observations showed that the interspinous ligaments give rise to similar referred pain, and as these structures are strictly segmental and easily accessible, I decided to map out as completely as possible, the various segmental pain areas by stimulating each of these ligaments in turn.

Two prominent vertebral spines were identified by marking them with lead and X-raying them, and the interspinous ligaments were then labelled accordingly†; it being assumed that the corresponding ligaments lie above the spines in the cervical region, but below the spines in the thoracic and lumbar regions, thus allowing for an 8th cervical ligament to correspond with the 8th cervical nerve. The observations were made upon myself and other workers in the laboratory.

As in previous observations upon muscle, the pain was produced by injecting 0·1 to 0·3 c.c. of 6% saline into the structure to be tested. The method of injection is simple. Having marked the position of the ligament to be tested, the overlying skin, fascia and supraspinous ligament are anæsthetised with novocaine as these structures give rise to local pain which may be confusing. The injecting needle is then introduced exactly in the mid-line and passed through the supra-spinous ligament. It is then moved slightly to one side until the tough interspinous ligament is felt with the needle point. At this moment the subject feels a unilateral pain, and at this point the saline is injected. If the injection is correctly placed the resulting pain is confined to one side of the body, but if the injection is placed exactly in the mid-line a bilateral pain is produced.

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† In which I have been helped by Dr. H. Nicholson to whom my thanks are due.

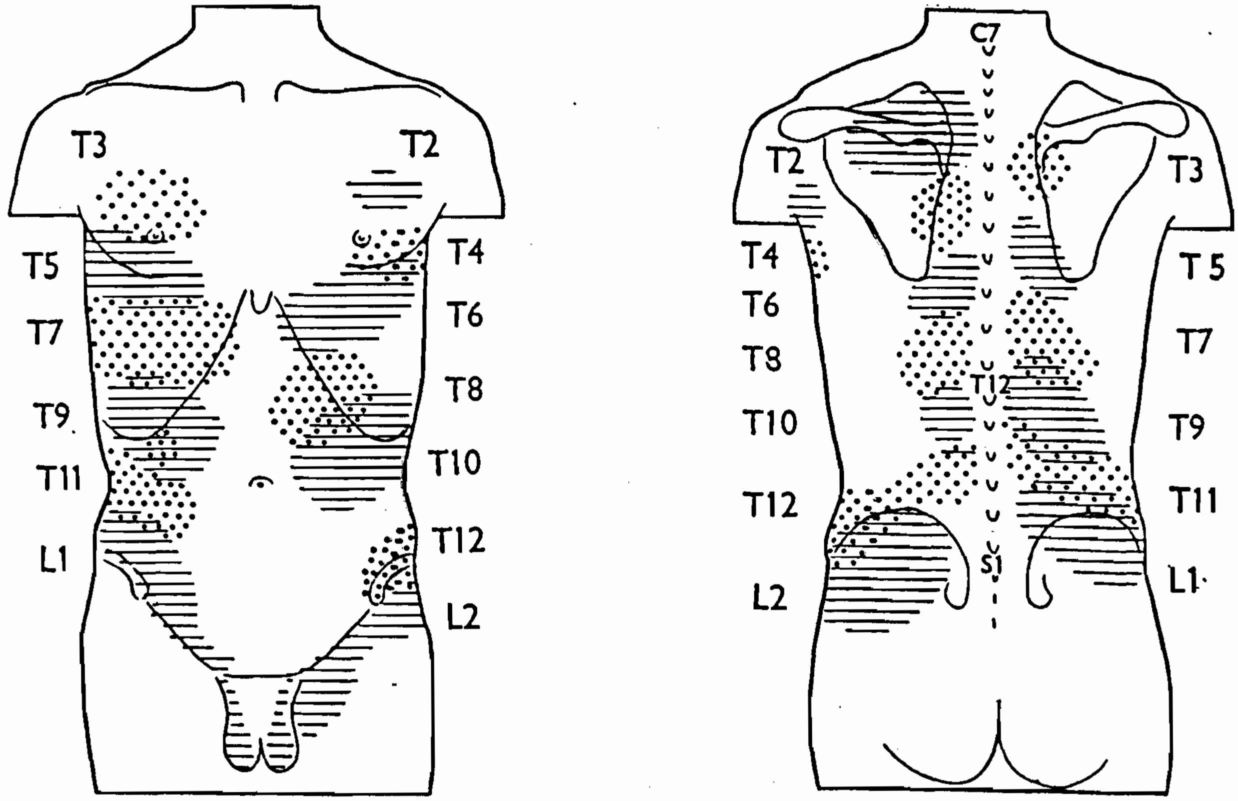


Fig. 1. Shows the distribution of pain arising from the interspinous ligaments T 2 to L 2. Alternate areas have been hatched and stippled.

This ligamentous pain is exactly similar in character to the pain produced from muscle, being a continuous ache lasting from three to five minutes, and described as felt deeply in the limbs and trunk. It is associated with tenderness of the deep structures. The distribution of this deep tenderness corresponds with the distribution of the pain, and its presence enables the subject to mark out the limits of the areas involved with some accuracy. The areas marked out in this way are then recorded on a diagram. Repeated injections of the same ligament gave remarkably constant results, although a period of days or weeks elapsed between the observations.

The interspinous ligaments were injected in turn from the 5th cervical to the 5th lumbar, and a further injection was made over the upper part of the sacrum, this being assumed to represent the 1st and 2nd sacral segments. The lower sacral and coccygeal areas were not obtainable because of the lack of segmental tissue in this region ; and the 5th and 6th cervical areas were only obtained with difficulty, because of the depth at which the spines lie in the neck. The areas of pain and tenderness marked out in this way are shown in the accompanying five figures.

The pain areas of the trunk are shown in Fig. 1. This distribution was studied in three different subjects, but there was so little individual variation that one example only has been reproduced.

The pain areas of the arm are shown in Fig. 2. Here the distribution of pain arising from each interspinous ligament is shown separately, and

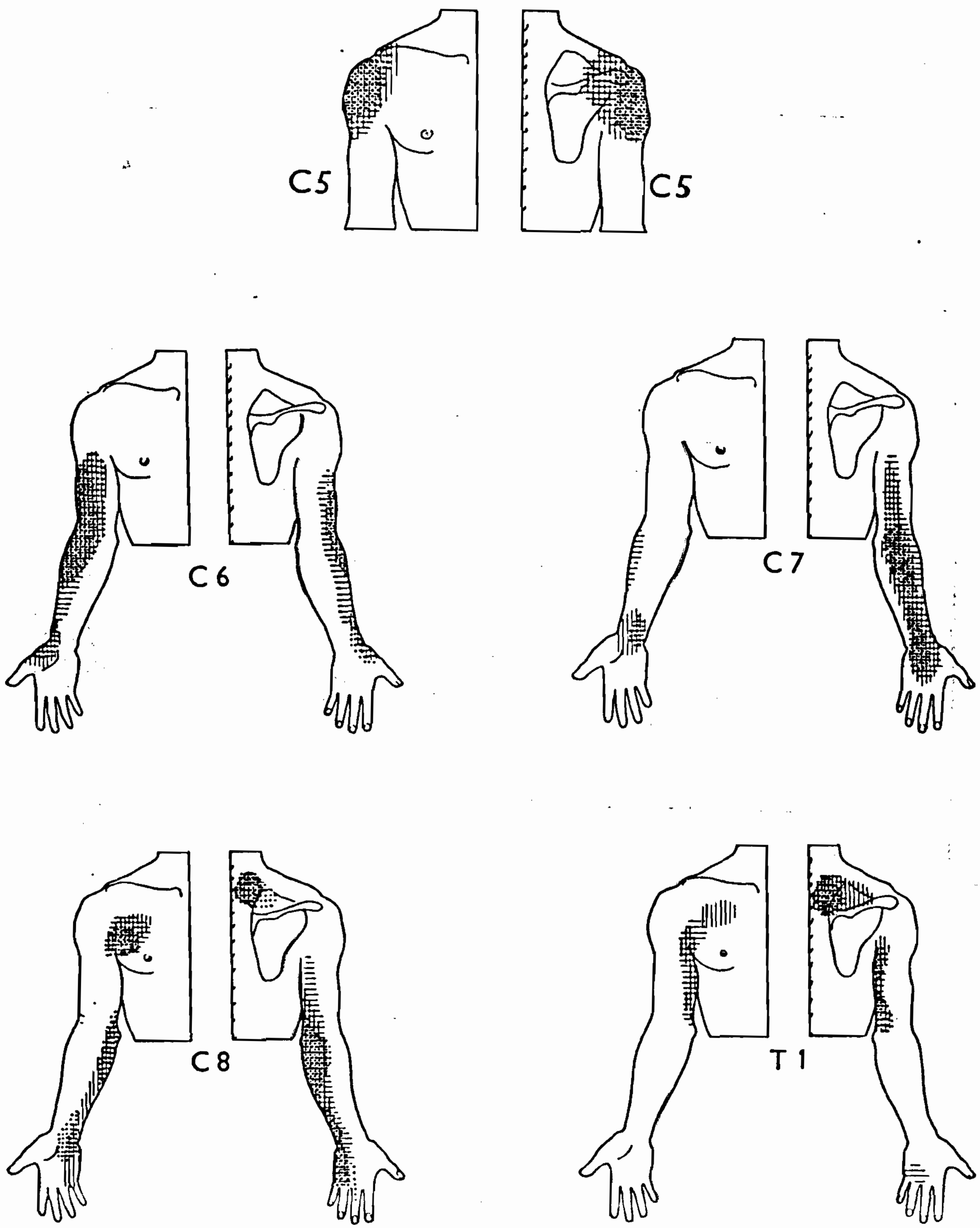


Fig. 2. Shows the distribution of pain arising from the interspinous ligaments C 5 to T 1 in 3 subjects; vertical hatching, horizontal hatching and stippling.

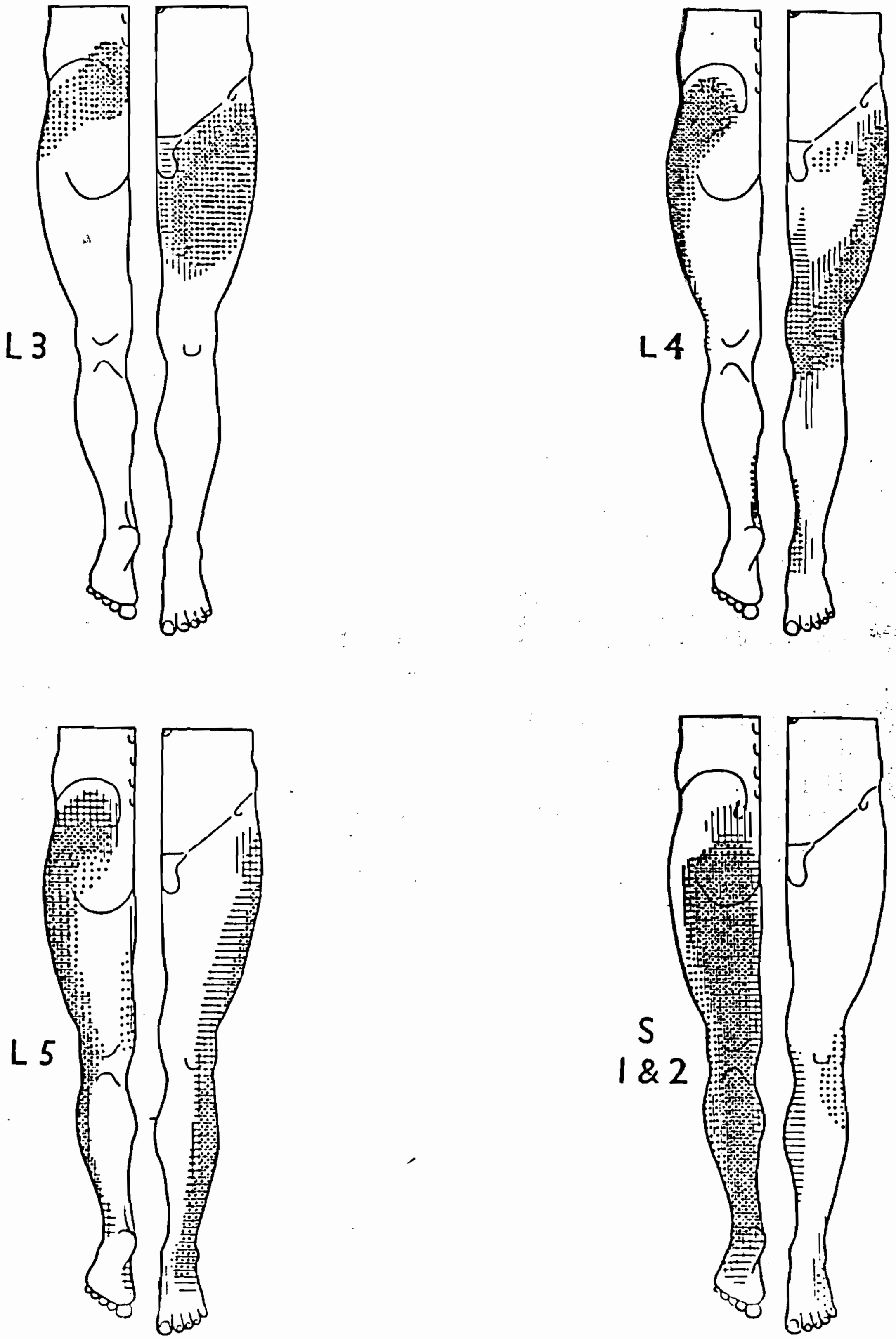


Fig. 3. Shows the distribution of pain arising from the interspinous ligaments L 3 to S 2 in 3 subjects, vertical hatching, horizontal hatching and stippling.

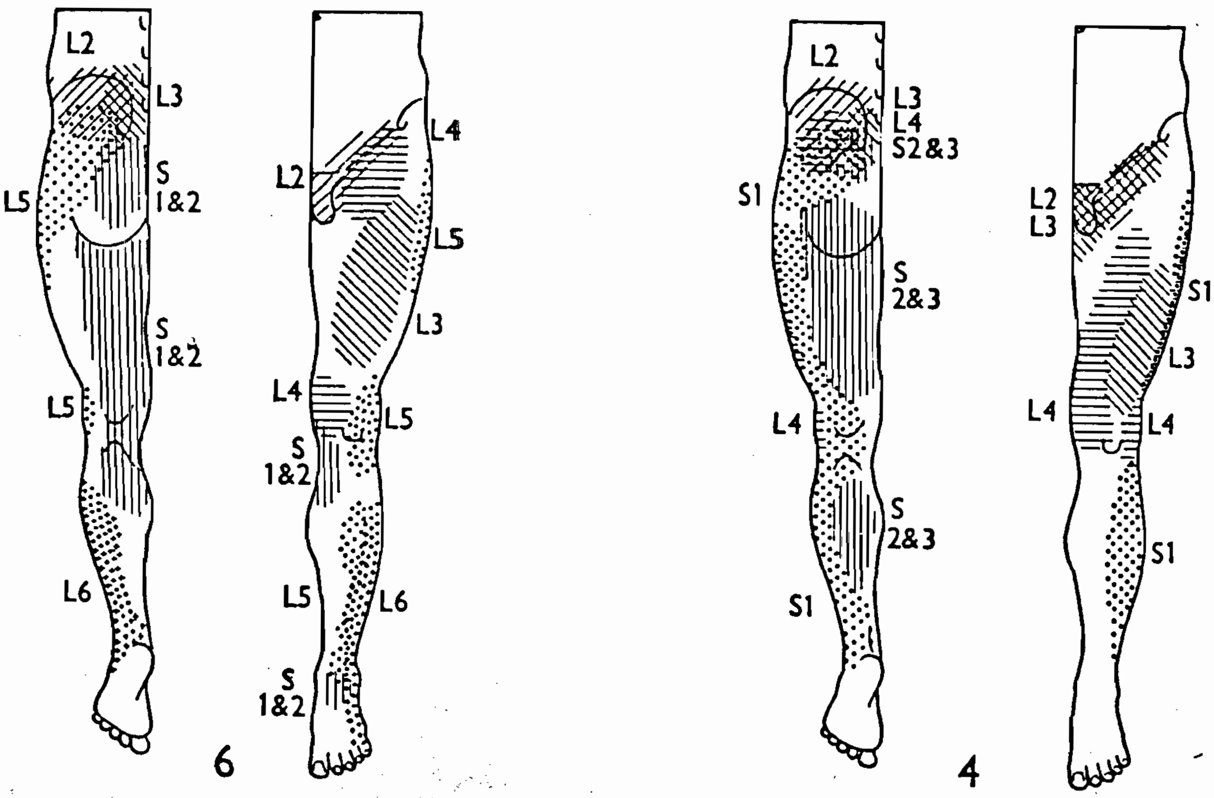


Fig. 4. Shows the distribution of pain arising from the interspinous ligaments L 2 to S 2, in 2 additional subjects, one of whom had 6 lumbar vertebræ while the other had but 4.

represents the superimposed results from 3 subjects. In this way the individual variation is displayed and a common area is obtained where there is overlap. Some of these pains were associated with peculiar sensations in the fingers, but as the subjects had some difficulty in deciding which fingers were involved these sensations were not recorded.

The pain areas in the leg are shown in Fig. 3. Here again the distribution of pain arising from each interspinous ligament is shown separately, and represents the superimposed results from 3 subjects.

The pain areas in the leg were also mapped out on one subject who had 6 lumbar vertebræ, and on another who had but 4 (Fig. 4). These two subjects had their entire spines X-rayed, and they were found to be made up as follows :—The first consisted of 7 cervical, 12 thoracic, 6 lumbar, 5 sacral, and 3 coccygeal ; the second consisted of 7 cervical, 12 thoracic, 4 lumbar, 6 sacral and 3 coccygeal vertebræ. It will be noticed that the distribution of the pain areas in these subjects differs considerably from that of the 3 normals. This difference is not simply a caudal or cephalic shift, but is a redistribution of all the areas in the leg. As the frequency of such abnormalities is said to be 6% (1) these differences may be of some clinical importance.

The pain areas in the arm arising from the interspinous ligaments of another subject are shown in Fig. 5 for comparison with the areas of pain which were previously (4) mapped out from his arm muscles. It will be noticed that although the general pattern obtained by the two methods is similar, there are considerable differences, particularly in the eighth cervical and first thoracic areas. In mapping out pain areas from the arm muscles it was assumed that certain muscles were innervated from a known single segment. This is, of course, only approximately true, and in this subject it is clear that the distribution of pain arising from the interosseous muscle resembles the distribution of T.1 rather than C.8, which it was at first assumed to represent. This subject is also unusual in that he consistently gives smaller areas of pain than the other subjects.

*Comment.* The distribution of the segmental areas obtained from the interspinous ligaments does not correspond exactly with the distribution of the dermatomes as demonstrated by Foerster (2) or with the areas of skin tenderness recorded by Head (3), and I suggest that the distribution of these areas of deep pain and tenderness may correspond with the distribution of the segmental innervation of some of the deep structures.

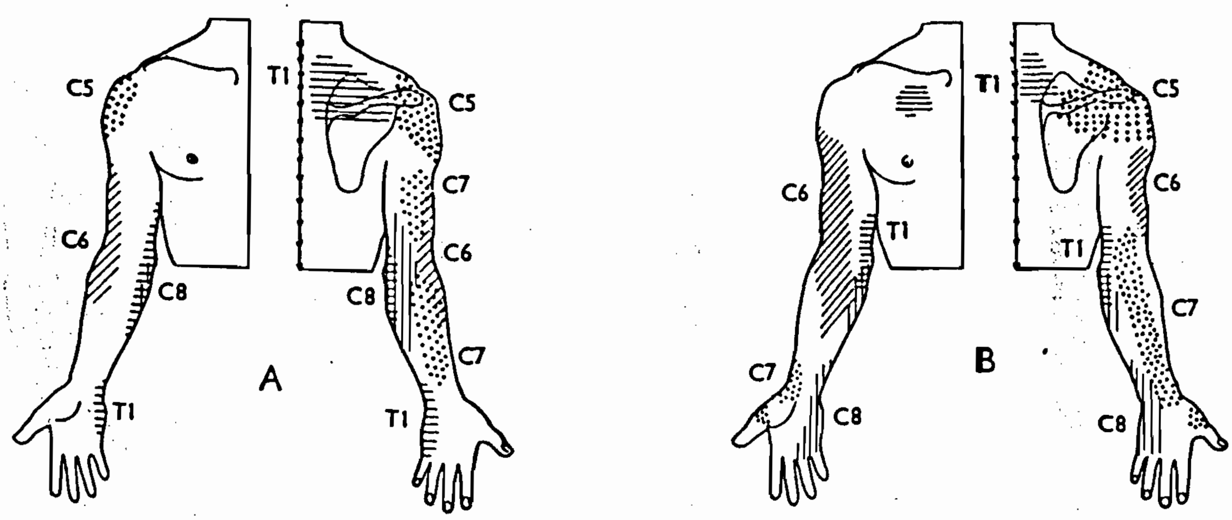


Fig. 5. *A.* Shows the distribution of pain arising from the interspinous ligaments C 5 to T 1 in another subject.

*B.* Shows the distribution of pain arising from his arm muscles. Crosses pain from rhomboids; oblique hatchings from flexor carpi radialis; stippling from abductor policis longus; vertical hatchings from third dorsal interosseous; horizontal hatching from first intercostal space.

## *Pain from other deep structures.*

The segmental pain areas arising from the interspinous ligaments having been mapped out, the next step was to determine to what extent pain arising from other deep structures is referred over these areas or felt locally. The distribution of muscular pain had been determined previously (4) so that only the pain arising from structures such as the fascia, periosteum, tendons, and joints remained for investigation. The pain was again produced by injecting small quanitites of hypertonic saline into the structure to be tested. Membranes such a fascia and periosteum were also stimulated by scratching them with the needle point as by this method alone could one be certain of stimulating the membrane itself without surrounding structures. Unfortunately the pain produced by scratching with a needle is only of momentary duration, so that although it can be recorded as felt in a certain region, it is too fleeting to allow the limits of its distribution to be mapped out.

The following method was therefore employed. A hypodermic needle was passed through anæsthetic skin and made to impinge upon the portion of fascia or periosteum to be tested. The membrane was then scratched with the needle point, and the region where the subject felt pain was marked

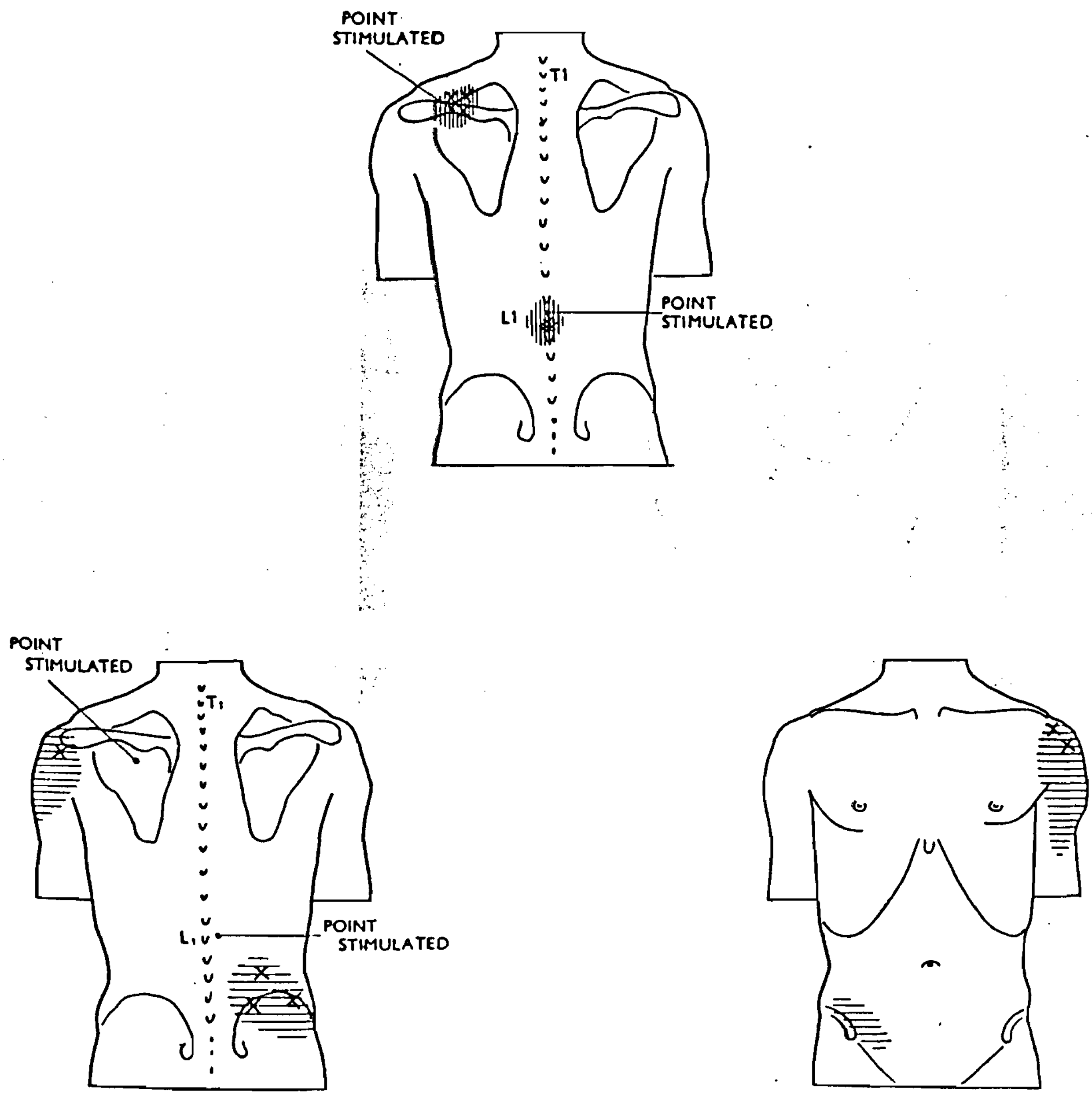


Fig. 6. Shows the distribution of pain produced by saline from subcutaneous periosteum (vertical hatching) and deeply situated periosteum (horizontal hatching). Points stimulated are tip of spine and lamina of first lumbar vertebra and the spine and infraspinous fossa of the scapula. The crosses indicate where pain was placed when the periosteum at the site of injection was scratched with the needle point (3 observations).

with a cross. This was repeated at least three times; after which saline was injected and the distribution of the resulting pain was mapped out. Fig. 6 illustrates the type of result obtained when different portions of periosteum are stimulated in this way. It will be seen that pain arising from subcutaneous periosteum is confined to the neighbourhood of the point stimulated, while pain arising from deeply situated periosteum is felt diffusely and may be referred. It will also be noticed that when saline gives rise to pain which is more or less local, the momentary pain produced by the needle point is regularly placed at the same spot; but that when saline gives rise to diffuse pain, the pain produced by the needle point is placed in various situations, but always somewhere within the distribution of the saline pain.*

Numerous observations of this kind were made on different subjects; but as it would be too tedious to record all of them in detail, the general results will be described and illustrated by a few typical examples.

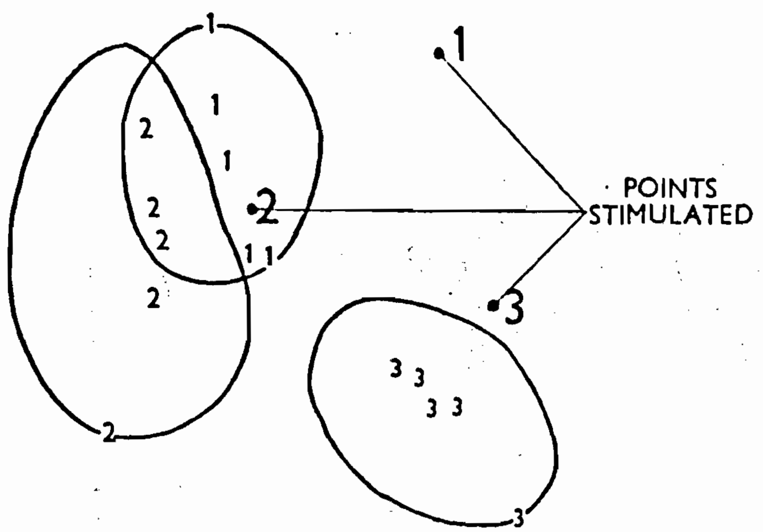


Fig. 7. Is a diagrammatic representation of pain arising from 3 points (1, 2 and 3) on the gluteal fascia 4 cm. apart. Small numbers show where momentary pain from corresponding needle point was placed; circles indicate the limits of pain from saline injected at the same point. (Skin localisation was accurate to within 1 cm.).

Fig. 7 illustrates the distribution of pain arising from deep fascia. It will be seen that the pain produced by saline is not felt diffusely but is confined to a small region, and that the pain produced by the needle point is regularly placed within the distribution of the corresponding saline pain. The pain, however, is not always placed over the point stimulated. On the other hand it is not felt at any great distance from that point, so that although this pain is not accurately localised to the point stimulated it may still be called local as distinct from diffuse in distribution.

Local pain of this type is obtained from all the deep fascia covering the trunk and limbs and also from subcutaneous areas of periosteum such as are

* When a needle is driven firmly into bone it gives rise to an unpleasant sensation of pressure. This sensation appears to be accurately localised, and should not be confused with the pain produced by scratching the periosteum.

found on the tibia, patella, sternum, vertebral spines, acromion, olecranon and phalanges. Subcutaneous ligaments and tendon sheaths such as those at the ankle and wrist, and tendons such as the patellar tendon and tendo achilles also give rise to this type of local pain though the pain may be felt over a larger area when it is severe. On the other hand the intermuscular planes of fascia and deeply situated periosteum and ligaments do not give rise to such local pain but to diffuse pain. From this it is clear that whether pain arising from a given structure is felt diffusely or is confined to the region of that structure depends more upon whether the structure stimulated lies superficially or deeply, than upon its nature (whether fascia, ligament or periosteum). This is well illustrated by pain arising from the chest wall (Fig. 8). Here local pain is only obtained from the fascia and periosteum which is subcutaneous in situation while all the structures situated more deeply give rise to diffuse pain of segmental distribution, whether the structure stimulated be muscle, ligament or periosteum.

In some regions the segmental distribution of diffuse pain may be modified by a crude attempt at localisation. For instance, pain arising

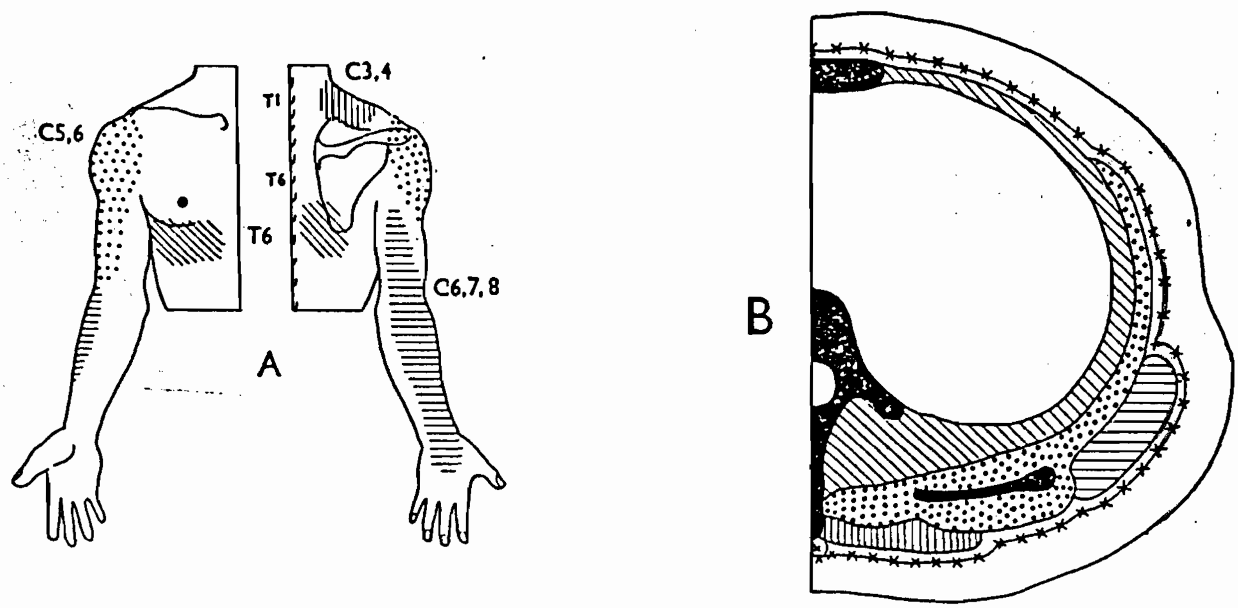


Fig. 8. A. Shows the distribution of pain arising from the various deep structures of the chest wall at the level of the 6th intercostal space. B. shows the tissues which give rise to the corresponding areas of pain. Oblique hatching, represents the intercostal space and erector spinæ (T 6); stippling, the muscles attached to the scapula, (C 5, 6); horizontal hatching, latissimus dorsi (C 6, 7, 8); vertical hatching, trapezius (accessory nerve and C 3, 4). Crosses represent tissue giving rise to local pain which is not shown in A.

from the erector spinæ may be felt more in the back than the front, while pain arising from the rectus abdominis is felt more in the front than the back. The segmental distribution of pain arising from the limb muscles is modified to a greater extent. Thus pain arising from the anterior crural muscles is felt maximally in front of the ankle, and pain from the extensors of the fingers is felt over the dorsum of the hand; similarly pain arising from the long flexors of the fingers is felt maximally in the region of the wrist and knuckles. In general there is a tendency for pain arising from the limb muscles to be placed in the region of the joints which are moved by these muscles, provided these joints lie within the segmental pain areas corresponding to the nerve supply of the muscles in question.

In pain arising from the limb joints themselves localisation is more accurate. Fig. 9 illustrates the distribution of pain arising from different parts of the knee. Although the distribution of these pains follows the distribution of the segmental pain areas to some extent, there is in all of

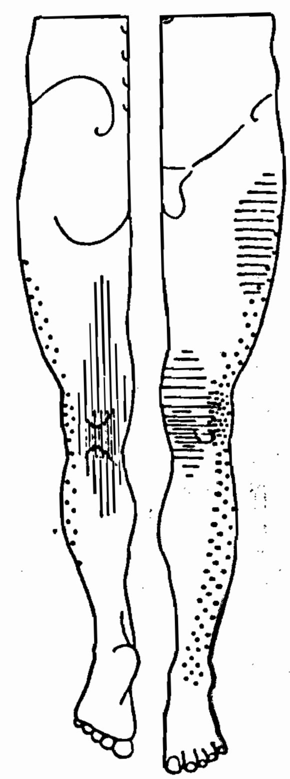

Fig. 9. Shows the distribution of pain arising from structures round the knee. From medial collateral ligament, horizontal hatching; from lateral part of capsule, stippling; from posterior part of capsule, vertical hatching.

them an area of maximal pain in the region of the knee, and when the pain is of slight intensity this area of maximal pain may alone be appreciated. Similar results are obtained from other joints, though pain arising from the joints of the hand and foot is more local, while pain arising from the hip and shoulder is more segmental in distribution.

With the stimuli used I was unable to produce any pain from either articular cartilage or compact bone, though cancellous bone gave rise to diffuse pain similar to that arising from the other deep structures.

Articular cartilage was investigated during the aspiration of fluid from distended knee joints. Whenever the aspirating needle was driven into the cartilage covering the lower end of the femur or the patella the subject experienced a sensation of "tapping" or "pressing" but no pain; but whenever the needle impinged upon the lining of the suprapatellar pouch the subject experienced severe pain felt "somewhere in the knee." This result was obtained from 4 subjects.

Bone was investigated in the following way. One of my surgical colleagues drove a Kirschner wire through the upper end of my own tibia, after the overlying skin and periosteum had been thoroughly anæsthetised with novocaine. While the wire was passing through the compact bone I experienced a sensation of pressure and vibration but no pain, but when the wire entered the soft cancellous bone diffuse pain was added to the sensation of vibration. The wire was then replaced by a hypodermic needle and 0·1 c.c. of 6% saline was injected into the cancellous bone. This also gave rise to slight diffuse pain felt widely in the outer side of the leg.

### *Discussion.*

From these observations it would seem that beneath the skin there is a second sensitive layer in which pain is localised with fair accuracy. This layer consists of the deep fascia encasing the limbs and trunk and any periosteum, ligament or tendon sheath which is situated subcutaneously. On the other hand all the structures deep to this layer give rise to diffuse pain of more or less segmental distribution. The pain is fully segmental in distribution when arising from the interspinous ligaments, intercostal spaces, and other structures situated deeply in the trunk and limb girdles; while the pain is more local when arising from the extremities, the joints, and the less deeply placed structures in the limbs and trunk.

Pain is usually considered to be of two types "local" and "referred"; the latter having a segmental distribution and a special neurological mechanism. Pain arising from the somatic deep structures, however, presents a gradual transition from pain which is confined to the region of the structure stimulated to diffuse pain of full segmental distribution, and in either case the situation of the point stimulated may or may not lie within the distribution of the pain. Thus a classification into "local" and "referred" pain cannot be applied consistently. Instead we have to speak of pain which is moderately well localised, and diffuse pain which is poorly localised.

The better localised pain is obtained from the more superficial body coverings, and from the limb joints and other structures of which we are conscious as a result of palpation and movement, while diffuse pain is obtained from the more deeply situated structures of which we are ordinarily unconscious. This diffuse pain appears to be projected to the region of those deep structures in which pain is well localised and which are innervated by the same spinal segment as the structure stimulated; in this way the pain is given its segmental distribution. Thus, the segmental distribution of diffuse pain may simply be a form of false localisation.

### SUMMARY.

1. Segmental areas of deep pain and tenderness have been mapped out by stimulating the interspinous ligaments.

2. An extensive investigation has been made of the distribution of pain arising from the various deep somatic structures, and it has been found that they give rise to pain, the distribution of which presents a gradual transition from pain which is confined to a spot in the region of the structure stimulated, to diffuse pain of full segmental distribution.

3. Whether the pain is local or segmental in distribution appears to depend more upon the depth at which the tissue stimulated lies than upon its nature (whether muscle, ligament or periosteum).

4. These findings are briefly discussed, and it is suggested that the segmental distribution of diffuse pain may be a form of false localisation.

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