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Muscle fibre direction of longissimus, iliocostalis and multifidus: landmark-derived reference lines*

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INTRODUCTION

Power density spectrum analysis of the electromyographic signal in the assessment of localised muscular fatigue has found a renewed interest in clinical research (De Luca & Roy, 1988; Biedermann & Shanks, 1987) with new technologies being developed to measure changes in the frequency spectrum during sustained muscle contraction (De Luca, 1984). Previous investigations have indicated that during sustained muscular contractions the frequency component of the surface-recorded electromyographic signal shifts towards the lower end with fatigue (Okada, Kogi & Ishii, 1970; Andersson, Ortengren & Herberts, 1977; De Luca, Sabbahi, Stulen & Bilotto, 1983). The shift towards lower frequencies (compression) has been related to a decrease in the conduction velocity of the muscle fibres (e.g. Stulen & De Luca, 1981), which has, in turn, been attributed to the accumulation of metabolic by-products such as lactic acid.

Because this technique relies on surface electrodes, and since the recorded frequency parameter changes are directly related to changes in the conduction velocity of the muscle fibre, proper placement of the surface electrodes with respect to the muscle fibre direction is critical for obtaining valid frequency parameters. Each electrode, which is specifically designed for this purpose (NeuroMuscular Research Laboratory, Boston University) contains two parallel silver bars 10 mm apart, each bar being 0·5 mm wide and 10 mm long. These electrodes have to be placed over the selected muscle with the electrode bars perpendicular to the muscle fibres. Although muscle fibre directions may be guessed reliably for some muscles such as the biceps, the more complicated muscular structure of the back requires well-grounded reference data.

Unfortunately, recent attempts by our group (Biedermann & Shanks, 1987) and by others (De Luca & Roy, 1988) to use this technique in the investigation of paraspinal muscle fatigue parameters in patients suffering from musculoskeletal back pain have been hampered by the fact that the anatomical literature provides little information about muscle fibre directions in the lumbar region. Anatomical texts describe muscles mainly in terms of origins and insertion while atlases provide largely a general-schematic representation of the paraspinal musculature (Williams & Warwick, 1980; Anderson, 1983; Hollinshead & Rosse, 1985; Clemente, 1985; O'Rahilly, 1986). Similarly, recent investigations of the lumbar paraspinal musculature give muscle fibre directions only as rostromedial or rostrolateral, and do not mention specific angles

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Table 1. *Muscle fibre angulation of the iliocostalis, multifidus and longissimus*

	X	S.D.	Range	*N*
Iliocostalis lumborum				
Fibre direction angle from spine	13·0	2·11	11·5–17·0	6
Fibre deviation angle from reference line	0·4(m)	1·50	±1·8	6
Multifidus				
Fibre direction angle from spine	15·1	1·43	13·5–18·0	4
Fibre deviation angle from reference line	0·1(m)	0·95	±1·0	4
Longissimus thoracis				
Fibre direction angle from spine	0·8	7·67	9·0(m)–9·8(1)*	5
Fibre deviation angle from reference line	No reference line found			

X, Mean (degrees); S.D., Standard Deviation; (m), medially; (l), laterally.
* The total range of angulation, medial to lateral, is 18·8.

(Bogduk, 1980; Bustami, 1985). While photographic atlases are more detailed, little can be learned from them about the reliable estimation of paraspinal muscle fibre direction (Snell, 1978; Rohen & Yokachi, 1983; Han & Kim, 1985).

In order to obtain accurate information about muscle fibre directions in the lumbar region (longissimus, multifidus, iliocostalis) a cadaveric study was carried out. It sought to investigate whether easily identifiable surface anatomical landmarks could be used in the determination of paraspinal muscle fibre directions.

MATERIAL AND METHODS

The iliocostalis lumborum was studied by detailed gross dissection in six embalmed adult male cadavers while study of the longissimus and the multifidus was limited to five and four cadavers respectively. Following reflection of the latissimus dorsi, the erector spinae aponeurosis was resected between the spinous processes and the medial edge of the iliocostalis lumborum to reveal the fibres of the longissimus and multifidus which lay deep to it. Segmental dissection of these muscles, by making transverse incisions and removing the caudal portion of the superficial fibres, facilitated the determination of their fibre directions.

Direct measurement of the fibre angles on the cadaver proved to be impractical due to some degree of undulation of the flaccid muscle fascicles. In order to improve angle measurement accuracy, estimations were obtained from photographs taken in the plane of the back; the reduction of the image reduced the amplitude of the undulations, thus making the fibre directions easier to discern.

RESULTS

Initially, a two dimensional grid system was employed, using easily palpable landmarks (i.e. the vertebral spinous processes and the lateral border of the iliocostalis), to define the angulation of the muscle fibres in various sectors. As Table 1 indicates, the large range of angles of the muscle fibres of the muscles concerned questions the applicability of this approach.

A further examination of the cadavers revealed that (i) the slips of the iliocostalis, inserting into their respective ribs, ran parallel to each other, and that (ii) the fibres of this muscle also ran parallel to a line which is defined by the caudal tip of the posterior superior iliac spine and the lateral border of the iliocostalis at the twelfth rib (Fig. 1).

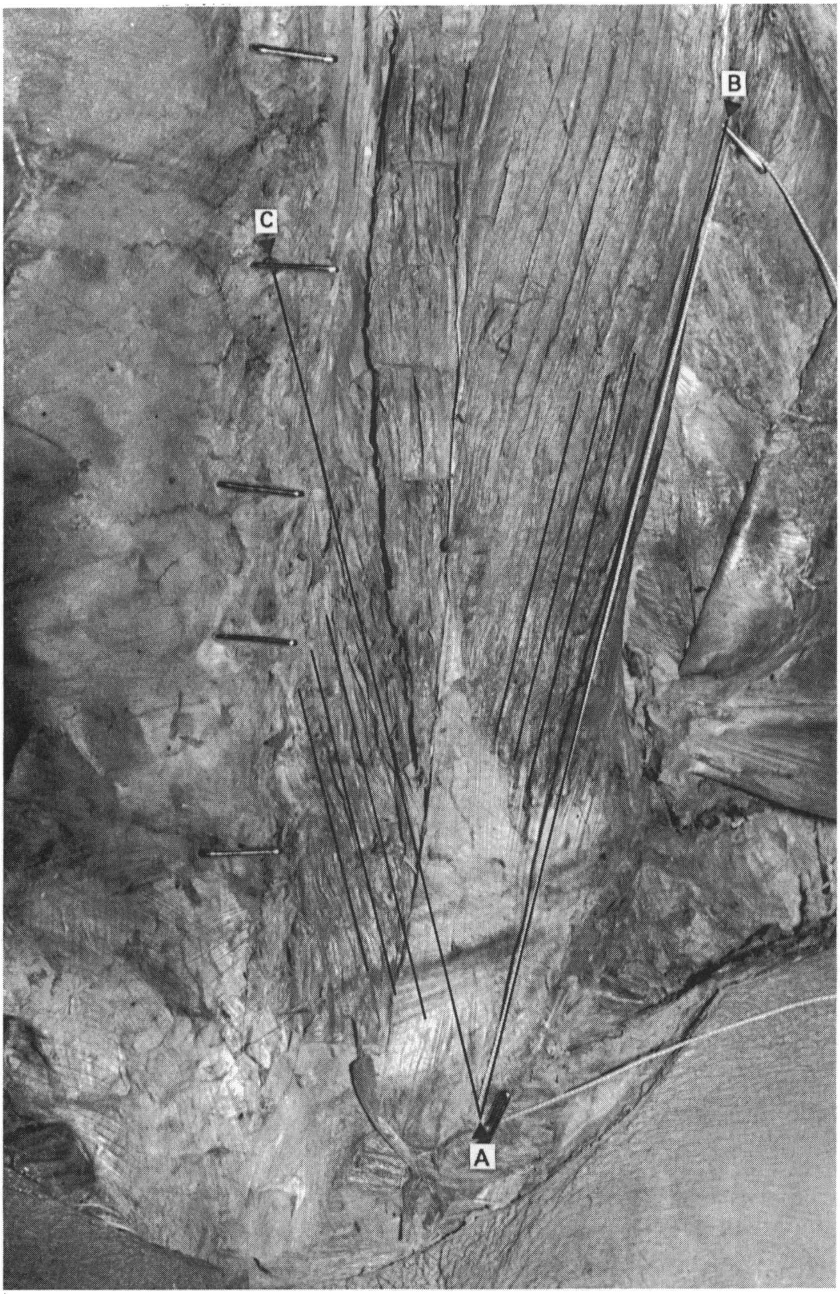

Fig. 1. The five vertically aligned staples mark the interspinous spaces, with C indicating the L1–L2 space. Staple A marks the ipsilateral posterior superior iliac spine (P.S.I.S.) and staple B the lateral border of the iliocostalis at the twelfth rib. The fibres of the iliocostalis lumborum and the multifidus run parallel to lines defined by the ipsilateral P.S.I.S. to the lateral border of the iliocostalis at the twelfth rib (line AB) and to the L1–L2 interspinous space (line AC) respectively.

Similarly, the fibres of the multifidus were observed to run parallel to a line between the posterior superior iliac spine and the L1–L2 interspinous space. No reliable landmarks, however, were noted by which the direction of the longissimus fibres could be determined. The average deviations of the muscle fibre directions for the iliocostalis lumborum and the multifidus with regard to their respective reference lines are listed in Table 1. As the data indicate, the landmark-derived reference line method of muscle fibre direction estimation is superior to the previously investigated two dimensional grid system, and falls within the limits of accuracy required for the placement of surface electrodes relative to a reference line drawn on the skin.

DISCUSSION

Based on a recently developed technology which measures changes in the frequency spectrum during sustained muscle contractions via surface electrodes, investigations are under way to assess paraspinal muscle fatigue patterns in patients with chronic back pain. Since the recorded frequency parameters are related to changes in conduction velocity of muscle fibres, knowledge about the direction of the fibres is essential for obtaining valid frequency parameters. Unfortunately, the literature fails to provide quantitative information related to muscle fibre directions in the lumbar region.

The present cadaveric study was carried out to provide details of the muscle fibre directions for the longissimus, iliocostalis lumborum and multifidus. The data revealed that an initially applied two dimensional grid system, which provided data of the degree of angulation at a given level, was unsatisfactory; inter-individual variations of up to 5·5 degrees were noted. However, highly reliable estimates of muscle fibre directions were obtained by drawing a straight line between the caudal tip of the posterior superior iliac spine and (i) the lateral border of the iliocostalis at the twelfth rib, and (ii) the L1–L2 interspinous space. The former reference line follows closely the muscle fibre direction for the iliocostalis lumborum, the latter for the multifidus. No index was found, however, for the longissimus. All three landmarks required for the identification of the respective muscle fibre directions are easily palpable. (Note: two of six cadavers were observed to have bifid posterior superior iliac spines, of which the caudal one has to be used for obtaining the reference lines.)

The dissections also revealed that the above described electrodes would encounter minimal electrical interference from the longissimus and iliocostalis lumborum if placed medially to the multifidus reference line at the L4–L5 interspinous space. A parallel line 10 mm medial to the iliocostalis reference line is recommended for the assessment of electromyographic parameters of the iliocostalis lumborum. This ensures that the electrode will be placed well over the muscle, as the reference line also demarcates the lateral border of the iliocostalis lumborum. The fibres of this muscle, which are superficial to the erector spinae aponeurosis, are relatively thin at the L3–L4 interspinous space and generally absent at the L4–L5 space. In addition, the caudal limit of the latissimus dorsi extends to the level of the L1–L2 interspinous space. Thus, the L2–L3 level is seen as being optimal as an electrode placement site, with many active fibres overlain only by the thin dorsal thoracolumbar fascia. This emphasises the limitations encountered when using surface electrodes in the recording of electromyographic activity of specific lumbar paraspinal muscles.

Since the results are based on male cadavers, a similar study may be warranted to determine the validity of these landmarks for fibre direction determination in females.

SUMMARY

Considerable inter-individual variations in the fibre direction angles of the iliocostalis lumborum, longissimus and multifidus were observed, thus bringing the applicability of a two dimensional fixed angle grid system for fibre direction determination into question. However, the angulation of the fibres of the multifidus and iliocostalis lumborum were found to be easily identifiable by the use of three surface anatomical landmarks: the caudal tip of the superior iliac spine, the lateral border of the iliocostalis at the twelfth rib and the L1–L2 interspinous space. No reliable index was found for the longissimus. Suggested electrode placement sites for the electromyographic study of the iliocostalis lumborum and the multifidus are at the levels of the L2–L3 and the L4–L5 interspinous spaces respectively.

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