The iliopsoas muscle and the lumbar spine

Agust Jorgensson

The influence of the iliopsoas muscle length on postural and mobility characteristics of the lumbar spine was investigated in 60 normal male subjects. The passive physiological and accessory intervertebral movements were assessed. Measurements which provided estimations of the lumbar lordosis, lumbar extension and iliopsoas muscle length were also recorded. A difference was found in the iliopsoas muscle length with respect to the mobility of the passive physiological and accessory intervertebral movements at the L1-L2 and T12-L1 segments, and at the L2 and L1 levels respectively. As the iliopsoas muscle shortened, the intervertebral mobility increased. Furthermore, the iliopsoas muscle length showed a weak tendency toward a correlation with the lordosis and the lordosis tended to increase as the muscle shortened. No correlation was found between the iliopsoas muscle length and the range of lumbar extension.

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The iliopsoas is the only muscle group in the body with direct attachments to the spine, the pelvis and the femur. Therefore it has the potential to influence, and be influenced by, movements at both the spine and the hip joints.

The iliopsoas is a postural muscle and has been observed to demonstrate a striking tendency to shorten (Janda 1978 and 1983). The few studies which have investigated the length of the iliopsoas have found that approximately 20-35 per cent of normal individuals show a 5 degrees or more extension deficit at the hip joint attributable to the iliopsoas muscle (Barber et al 1985, Hellsing et al 1987). In the two studies listed, the muscle length was tested by a procedure similar to the one recommended by Janda (1983).

When shortened, iliopsoas has been described as increasing the lumbar lordosis (Janda 1983, Kendall and McGreary 1983, Kennedy 1973 and 1978, Michele 1960 and 1963, Philips 1975, Weintraube 1986). However, only two studies have investigated this relationship, and neither of these demonstrated a significant relationship between iliopsoas length and any increase in lumbar lordosis (Barber et al 1985, Toppenberg and Bullock 1986).

Other authorities have also considered that a shortened iliopsoas muscle acts to limit the available range of lumbar extension (Ingber 1986, Weintraube 1986). However, no reported studies either support or dispute these claims. A shortening of the muscle group has also been suggested to limit lateral flexion to the contralateral side and ipsilateral rotation of the lumbar spine or, in cases of extreme shortening, to draw the lumbar spine into the opposite movement directions, thus causing a scoliosis or a list of the lumbar spine (Kennedy 1978, Michele 1963).

Similarly, components of compression and of anterior shear forces on the lumbar spine have been postulated to accompany the basic actions of the iliopsoas muscle (Gracovetsky et al 1977, Nachemson 1968, Troup 1975). These assumptions are based on geometry, mathematical calculations and clinical impressions, but have not been substantiated by research. Thus, although a shortening of the muscle group might be expected to enhance the accessory compression and shear forces, these have not been demonstrated experimentally or clinically. However, many physiotherapists use a regime of iliopsoas muscle stretching in the treatment of lumbar spine disorders in an effort to achieve optimal results. It is suggested by some practitioners that this may be important, especially in cases of hypermobility of the lumbar spine, which may be attributed to iliopsoas shortening.

In view of this knowledge, a study was devised to examine the nature of such a potential relationship.

Materials and methods

A sample of convenience, consisting of 60 male students ranging in age from 17 to 26 years (mean=19.5 years; S.D.=2.4 years) was recruited.

Subjects were excluded if they had:

a) any marked postural problems (for example a scoliosis or leg length discrepancy);

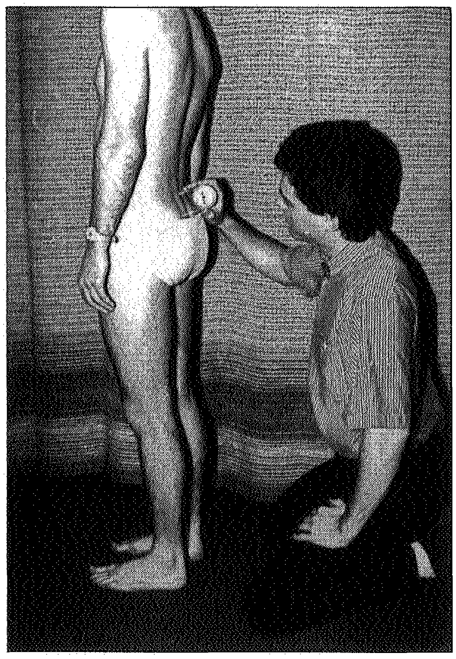

Figure 1.
Measurement of the incline at the S2 level.

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b) any previous major trauma or injury affecting their back or lower limbs; or

c) ever experienced problems/pain in their back or lower limbs which required medical treatment, limited activities of daily living or necessitated absence from school/ work.

Prior to their inclusion in the study, each subject was required to answer a questionnaire to ascertain their suitability for inclusion. The subject also provided an indication of the dominant or preferred leg (eg the one used for kicking a football).

The sequence of testing was standardised to include:

1. a) Passive physiological intervertebral movement tests (PPIVM) were conducted manually, commencing at the L5-S1 segment and proceeding cephalad to the T11-T12 segment. These tests were performed in the following order: Extension, right lateral flexion, left rotation, left lateral flexion, right rotation. This order minimised movement of the subject and made recording easier.

   b) Passive accessory intervertebral movement tests (PAIVM) were conducted manually, commencing at the L5 vertebra and proceeding cephalad to the T11 vertebra. These tests were performed in the following order: central postero-anterior vertebral pressure, right unilateral postero-anterior vertebral pressure, left unilateral postero-anterior vertebral pressure.

   The passive intervertebral movement tests were graded on an ordinal scale of one to five such that: 1=hypomobile; 2=slightly hypomobile; 3=normal; 4=slightly hypermobile; 5=hypermobile. Gonnella et al (1982) used a seven point scale to study the reliability in evaluating passive intervertebral movements, adding ankylosed (0) and unstable (6) to the scale used in the present study. The performance of five physical therapists in evaluating the movements of the lumbar spine in five normal subjects showed intratherapist reliability to be dependable while intertherapist reliability was not. Their conclusion was that in studies where passive intervertebral movements are used, the therapist as a source of variance should be kept constant, eg all evaluations done by the one therapist.

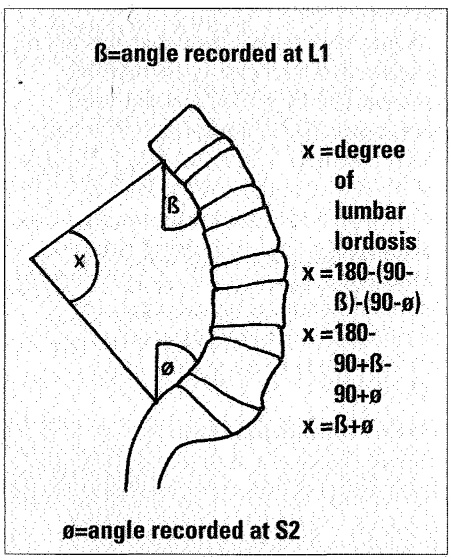

Figure 2.
Calculation of lumbar lordosis using the measured angles of inclination at L1 and S2.

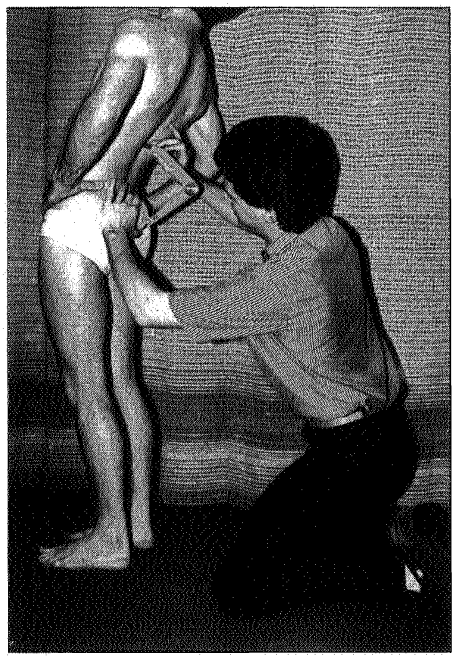

Figure 3.
Measurement of the lumbar extension.

2. To obtain an estimation of the lumbar lordosis, the standard Myrin goniometer, as modified by Grant (1984), was used to measure the inclines at the L1 and S2 levels (see Figure 1). From these values the angle of lordosis was calculated adapting the method proposed by Cobb (1960) in his measurement of the degree of curvature in subjects presenting with scoliosis. Figure 2 illustrates the geometry appropriate to this calculation. Other studies have previously used Cobb's (1960) method to calculate the lumbar lordosis (Barber et al 1985, Bullock et al 1987, Toppenberg and Bullock 1986).

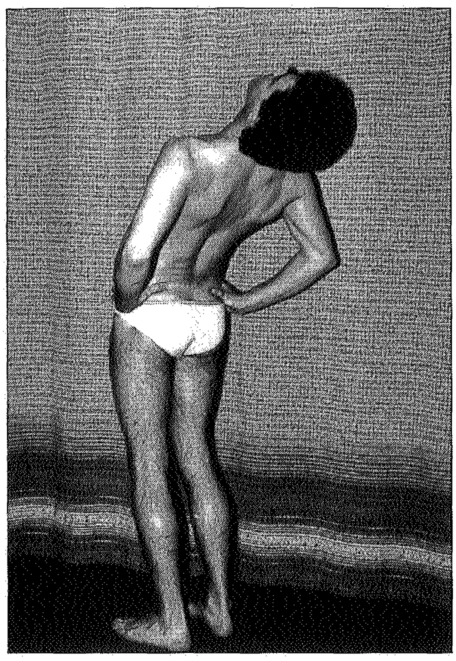

Figure 4.
Performance of the lumbar extension.

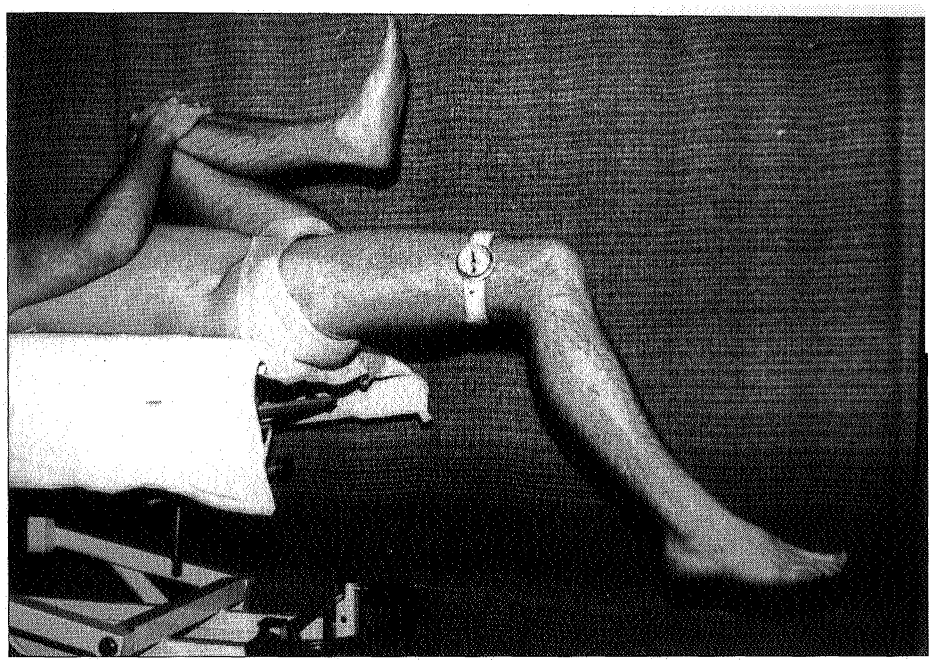

Figure 5.
Test position for measurement of the iliopsoas muscle length.

3. For measurement of the lumbar extension, a modified lumbar spondylometer designed by Grant (1984) was used to monitor the movement between S2 and T12 (see Figure 3). A posterior pelvic tilt was performed prior to the initiation of the movement but then permitted to be lost toward the end of the movement to ensure low lumbar extension (see Figure 4). The reason for preceding the extension by a posterior pelvic tilt was to flatten the lumbar lordosis and thus stretch the iliopsoas muscle. That stretch was then expected to be accentuated by the ensuing extension movement.
4. Estimation of the iliopsoas muscle length performed first on the right side and then on the left. As it is impossible to measure muscle length in vivo as an absolute value, the length of the iliopsoas was measured functionally using a method based on the one recommended by Janda (1983). It is admitted, however, that other intrinsic factors such as joint stiffness may play a role in limiting the maximum joint range achieved in the muscle length test. For the measurement, each subject was placed supine on the plinth with heels supported. Using a plastic ruler, a line was marked 5cm proximal to the superior edge of each of the patellae. A strap was applied to the thigh just proximal to these lines and a Myrin goniometer was attached to the strap by a Velcro fastening. The examiner then fully extended the subject's knees to ensure that the legs were lying straight on the plinth and the goniometer was calibrated to zero. Next, the subject slid down the plinth to stand at its edge. The subject was then asked to lie supine on the plinth with the coccygeal region just over the end, so that the lower limb to be tested would be free from any restraints offered by the plinth. While the examiner flexed the subject's non-tested lower limb at the hip and knee, the lumbar spine was palpated to ensure its flattening onto the plinth thus eliminating the lumbar lordosis. When the desired position had been attained, the subject was asked to hold the flexed knee with both hands and maintain the position. This positioning ensured that the lower limb to be tested hung freely over the edge of the plinth, and the subject was asked to relax the free hanging leg as much as possible (see Figure 5). Following a 20-second period which allowed for adequate relaxation, a reading was taken from the Myrin goniometer.

This sequence of testing also served to make the examiner blind to the results of the objective tests of the lumbar lordosis, lumbar extension and iliopsoas muscle length while performing the more subjective tests of PPIVM and PAIVM.

The examination was always carried out in the afternoon between one and six o'clock, to minimise the possible effects of circadian variations in flexibility (Gifford 1987).

Reliability procedures

To examine the intra- and inter-examiner reliability, five subjects were seen for each occasion. For the former, the subjects were seen by the examiner

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on two occasions a week apart, at the same time of the day and under the same environmental conditions. All skin markings were removed between sessions. For the latter, the examiner's ability in performing the measurements was compared against an experienced manipulative physiotherapist. The examiner performed each test first, followed by the manipulative physiotherapist. Both used the same skin markings. The intra-examiner reliability was 88 per cent for PPIVMs and 93 per cent for PAIVMs. The inter-examiner reliability were 86 per cent for PPIVMs and 86 per cent for PAIVMs.

From Table 1, it can be seen that there was a significant correlation for all the measurements obtained. No significant difference was observed except for the inter-examiner measurements of extension. Upon examination of the reliability data, it came evident that the manipulative therapist consistently obtained a value one to two degrees higher than the examiner. As the examiner always performed the initial measurement, this is likely to have occurred because of a slight mobilising effect from the previously performed movement.

Table 1.
Results of intra- and inter-examiner reliability procedures for measuring the lordosis, lumbar extension and iliopsoas length.

	Mean difference (SD/range)	*t* -value	*r*
Lordosis			
Intra-examiner	0.7° (1.34° / 0-2°)	$1.66_{(9)}$ (p =0.132)	0.979 (p =0.000)
Inter-examiner	0° (1.25° / 0-2°)	$0.00_{(9)}$ (p =1.000)	0.943 (p =0.000)
Extension			
Intra-examiner	0.7° (2.64° / 0-7°)	$1.19_{(9)}$ (p =0.250)	0.899 (p =0.000)
Inter-examiner	1.1° (1.45° / 1-2°)	$2.40_{(9)}$ (p =0.040)	0.979 (p =0.000)
Iliopsoas			
Intra-examiner	0.2° (1.75° / 0-2°)	$0.36_{(9)}$ (p =0.762)	0.981 (p =0.000)
Inter-examiner	0.5° (0.71° / 0-2°)	$2.24_{(9)}$ (p =0.052)	0.996 (p =0.000)

Results

Passive intervertebral movements tests: The means for these tests are shown in Table 2. The scores for lateral flexion, rotation and unilateral pressure on each side were averaged because when hyper- or hypomobility was found on one side, the other tended to show the same findings.

The lumbar lordosis, extension and iliopsoas muscle length: The mean values obtained for these measurements are reported in Table 3. A *t*-test analysis showed no significant difference to exist between the iliopsoas muscle length on the right and left sides ($t_{(59)}$=-1.62, p =0.110).

The iliopsoas muscle length and leg dominance: *t*-tests were used to identify any significant differences in the iliopsoas muscle length related to leg dominance. No significant

Table 2.
Passive intervertebral movement tests – the general distribution of mobility scores.

	PPIVM			PAIVM		Total
	Ext	LF	Rot	Central	Unilateral	
Hypomobile	4.1%	0.9%	1.5%	2.1%	0.7%	1.8%
Sl hypomobile	24.5%	12.5%	14.5%	21.7%	14.8%	17.6%
Normal	58.3%	79.2%	75.8%	68.8%	78.3%	72.1%
Sl hypermobile	12.9%	7.4%	8.2%	7.1%	6.0%	8.3%
Hypermobile	0.2%	0.0%	0.0%	0.3%	0.2%	0.2%

PPIVM=passive physiological intervertebral mobility; Ext=extension; LF=lateral flexion; Rot=rotation; PAIVM=passive accessory intervertebral mobility; Central=central pressures; Unilateral=unilateral pressures; Sl=slightly.

difference in muscle length could be attributed to leg dominance either on the left side ($t_{(57)}$=-0.80, p =0.427) or the right side ($t_{(57)}$=-0.87, p =0.389). For this reason, leg dominance was not further considered as a variable in any of the subsequent statistical analyses performed.

The iliopsoas muscle length and the passive intervertebral movement tests: A one-way analysis of variance was used to investigate any differences between the groups formed by the passive intervertebral movement ratings with respect to the muscle length of the iliopsoas.

Because of the rarity of the hypermobile and hypomobile ratings, it was necessary to collapse the rating system to obtain groupings of subjects of sufficient size for the analysis. Three groups were formed, a normal group (mobility score 3), an hypermobile group (mobility scores 4 and 5) and an hypomobile group (mobility scores 1 and 2). Even with these measures, the insufficient number of subjects meant it was sometimes only possible to compare the normal group with either of the other two.

A significant difference between groups with respect to the iliopsoas muscle length was demonstrated in the upper lumbar spine and at the thoracolumbar junction: that is, as the segmental mobility increased, the length of the iliopsoas decreased. This significant difference was demonstrated at the T12-L1 segment with respect to the PPIVMs tests of extension ($F_{(1,57)}$=7.2460, p=0.0093), lateral flexion right ($F_{(1,57)}$=7.3877, p=0.0087) and left ($F_{(1,57)}$=3.4477, p=0.0685), rotation right ($F_{(1,57)}$=8.0926, p=0.0062) and left ($F_{(1,57)}$=6.9420, p=0. 0108). At the L1-2 segment, this difference was likewise found with respect to the PPIVMs tests of extension ($F_{(1,56)}$=6.2024, p=0.0158), lateral flexion right ($F_{(1,57)}$=4.4654, p=0.0390) and left ($F_{(1,57)}$=9.0576, p=0.0039) but not with rotation right ($F_{(1,58)}$=1.2375, p =0.2706) nor left ($F_{(1,57)}$=1.9904, p=0.1637). This significant difference was similarly demonstrated at the L1 level with respect to the PAIVMs tests of central pressures ($F_{(1,57)}$=13.3478, p=0.0006), unilateral pressures right ($F_{(1,57)}$=2.7687, p=0.1016) and left

Table 3.
Mean values for the lumbar lordosis, extension and iliopsoas muscle length.

	Mean angle (SD/range)
Lordosis	29.1° (8.5°/8°-50°)
Extension	25.6° (7.0°/12.5°-48.5°)
Iliopsoas	-3.39° (6.18°/-19°-8°)

Table 4.
Iliopsoas muscle length with respect to the passive physiological intervertebral mobility at the T12-L1 and L1-L2 segments.

	Passive physiological intervertebral mobility Ext	LFR	LFL	RR	RL
T12-L1					
Muscle length (averaged for the right and left side)					
Grp 2 (Hypomobile)	-6.7222°	-10.6250°	-8.5000°	-7.5000°	-5.9167°
Grp 3 (Normal mobility)	-3.5233°	-3.1961°	-3.4510°	-3.9400°	-3.8750°
Grp 4 (Hypermobile)	1.0625°	0.4000°	0.3333°	2.2857°	3.0000°
L1-L2					
Muscle length (averaged for the right and left side)					
Grp 2 (Hypomobile)	-5.5000°	-7.1667°	-9.0000°	-5.5000°	-6.1110°
Grp 3 (Normal mobility)	-1.7097°	-2.5800°	-2.3824°	-3.0196°	-2.9600°

Ext=extension; LFR/LFL=lateral flexion right/left; RR/RL=rotation right/left.

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($F_{(1,57)}$=8.0264, p =0.0064). At the L2 level, this difference was likewise found with respect to the PAIVMs tests of central pressures ($F_{(1,57)}$=5.2987, p=0.0250), unilateral pressures right ($F_{(1,56)}$=7.7227, p=0.0074) and left ($F_{(1,56)}$=4.2080, p=0.0449). For the analysis with respect to the L1-L2 segment and at the L2, level only two groups were included in the analysis. However, at the T12-L1 segment and at the L1 level, all three groups were used in the analysis. Therefore, it was possible to test if they were linearly related in the analysis of variance (polynomial=1; weighted linear term) thus making the results more significant (see Tables 4 and 5).

When the non-significant findings were examined it was evident that the PPIVM test of extension demonstrated the same trend as the significant findings at all segments except at the T11-T12 segment where no definite trend could be observed. The PAIVM test of central pressure likewise showed the same trend at the L4, L3 and T12 levels while no definite trend was found at the L5 and T11 levels. With respect to the other passive intervertebral movement tests, no consistent pattern could be demonstrated.

The iliopsoas muscle length and the lumbar lordosis: The relationship between the iliopsoas muscle length and the lumbar lordosis was examined using the Pearson product moment correlation. It was apparent that a weak tendency toward a relationship existed such that when the muscle shortened the lordosis tended to increase (r =0.4033, p =0.001).

The iliopsoas muscle length and the lumbar extension: No significant relationship was found between the length of the iliopsoas and lumbar extension when their relationship was examined using the Pearson product moment correlation (r =-0.101, p =0.221).

Table 5.
Iliopsoas muscle length with respect to the passive accessory intervertebral mobility of the L1 and L2 levels.

	Passive accessory intervertebral mobility Central	Unilat R	Unilat L
L1			
Muscle length (averaged for the right and left side)			
Grp 2 (Hypomobile)	-8.1786°	-5.2333°	-7.2692°
Grp 3 (Normal mobility)	-2.1279°	-3.0357°	-2.5341°
Grp 4 (Hypermobile)	0.8333°	0.8333°	0.8333°
L2			
Muscle length (averaged for the right and left side)			
Grp 2 (Hypomobile)	-5.2222°	-7.0000°	-5.9118°
Grp 3 (Normal mobility)	-1.6406°	-2.1628°	-2.3780°

Central=central pressures; Unilat R/L=unilateral pressures right/left.

Discussion

Passive intervertebral movement tests: When the results from these tests were examined, a predominance of normal mobility scores was clearly established. This is not surprising as the sample used in this study comprised healthy young subjects. When a normal score was not obtained, a hypomobility score was a much more common finding than hypermobility. Extension and central postero-anterior vertebral pressure were the movements that demonstrated the highest number of hyper- and hypomobility scores. A general trend was seen for hypermobility scores to be concentrated in the lower lumbar spine and at the thoracolumbar junction, while the intermediate segments showed a higher frequency of hypomobile scores.

The lumbar lordosis: The mean angle of 29.1 degrees compared favourably with a mean angle of 26.6 degrees found by Barber et al (1985), using the same method to obtain an estimation of the lumbar lordosis in 20 male students aged 18-25 years.

The lumbar extension: Extension showed a mean value of 25.6 degrees. Lane (1981) employed a similar method to that described in this study and obtained a considerably lower mean angle of 17 degrees for 20 male students aged 15-24. Taylor and Twomey (1980) and Twomey (1979) likewise measured the sagittal range in 24 cadavers and 108 living male subjects respectively, aged 20-35. The mean range for extension in the cadavers was 13 degrees. The extension range for the living subjects was not specified but was said to be consistently lower than for the cadavers and less than 60 per cent of the flexion range. The total sagittal range was 42 degrees. The total sagittal range for subjects aged 13-19 was 45 degrees (Twomey and Taylor 1987). The difference between the values reported in the present study and these other two is at least partly the result of one additional vertebral segment being included in the measurement, namely the T12-L1 segment. Furthermore, with respect to the studies by Taylor and Twomey (1980) and Twomey (1979) the difference in age between subjects in these and in the present study might have played a role as the ranges of spinal movement have been shown to decline with age (Taylor and Twomey 1980). How the extension was performed might also have been important, as in the present study, the extension was preceded by a posterior pelvic tilt, whereas this was not the case in the other studies.

The iliopsoas muscle length: A value of minus 3 degrees was observed to correspond approximately to a horizontal position of the thigh during the testing procedure. The mean angle recorded in this study thus supports the normal position advocated by Janda (1983).

Furthermore, a 5 degree or more extension deficit at the hip joint attributable to the iliopsoas has been used as a criterion for marked shortening of the iliopsoas muscle (Hellsing et al 1987). Using this criterion, a marked shortening of the muscle was observed in approximately 33 per cent of the sample in the present study, which compares favorably with a value of 35 per cent obtained from 20 male students, aged 18-25, in Barber et al's (1985) study. Hellsing et al (1987) reported a considerably lower value of 21.5 per cent obtained from a sample of 999 subjects (18-19 years of age) but the gender of the subjects was not specified. The difference could be explained if a proportion of the sample were females, since Barber et al 1985 noted a marked shortening in only 15 per cent of 20 female students aged 18-25. Furthermore, Toppenberg and Bullock (1990), in their study of 103 adolescent females, found all angles for the iliopsoas muscle length to be below the horizontal.

The iliopsoas muscle length and the passive intervertebral movement tests: As the passive intervertebral movement tests performed in this study showed a very high percentage of normal ratings, definite conclusions are hard to reach. Nevertheless it can be stated that if the iliopsoas muscle affects the intervertebral mobility, the results reported would tend to suggest that shortening of the muscle would be most likely to cause increased mobility in the upper lumbar spine and at the thoracolumbar junction, especially in extension and anterior glide.

These findings thus support the assumptions made in the literature that the actions of the iliopsoas muscle are likely to be accompanied by anterior shear forces (Gracovetsky et al 1977, Troup 1975) and may contribute to the development of hypermobility.

The iliopsoas muscle and the lumbar lordosis: The correlation between the iliopsoas muscle and the lumbar lordosis support the clinical findings that a shortening of the muscle would tend to exaggerate the lumbar lordosis (Janda 1983, Kendall and McGreary 1983, Kennedy 1973 and 1978, Michele 1960 and 1963, Philips 1975, Weintraube 1986). The weak nature of the correlation is to be expected as other factors intrinsic (Farfan 1973, Last 1984, White and Panjabi 1978, Williams and Warwick 1980) as well as extrinsic (Toppenberg and Bullock 1986) have been shown to exert an influential effect on the curve.

When the results of this study are compared with those of others who have investigated the same relationships, there are some differences as Barber et al (1985) found no significant correlation between the lordosis and the iliopsoas muscle length. However, their sample was small (20 males, 20 females) and only a few subjects presented with a shortened muscle (8 males, 3 females). Toppenberg and Bullock (1986) likewise found no significant correlation between the lumbar curve and the muscle length of the iliopsoas. Their sample was quite different from the one used in this study, consisting of 103 adolescent females. This difference might account for the different relationship that was obtained, especially since the results of Barber et al (1985) suggest that shortening of the muscle may be more frequent in males.

The iliopsoas muscle and the lumbar extension: No significant relationship was observed between the iliopsoas muscle and lumbar extension. Thus the results from this study do not support the claims made by some authors (Ingber 1986, Weintraube 1986) that shortening of the iliopsoas muscle acts to limit lumbar extension.

Conclusion

Within the limitations of this study, it can be concluded that the iliopsoas muscle group exerts an influence on the lumbar spine, its posture and intervertebral movements. If shortened, the muscle may possibly contribute to some disfunction in the lumbar spine.

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