Measurement of Hip Range of Flexion-Extension and Straight-leg Raising

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Abstract We believe there is a degree of inaccuracy in the usual methods of evaluation of range at the hip in the sagittal plane, ie, flexion-extension. We describe a simple method of measuring more accurately the range of hip flexion-extension, presuming such ranges of motion should relate to the anatomic position of the pelvis. We used this technique for the measurement of flexion and extension of the left hip in a cohort of 200 healthy individuals; we found a wide range of both flexion (80°–140°) and extension (5°–40°). Especially with respect to extension, we believe more conventional methods underestimate the ranges of motion. As a corollary to this study, we suggest some reappraisal of the straight-leg-raising test by which pain from nerve root tension can be distinguished from a source of pain arising locally in intervertebral joints for mechanical reasons or from the hip itself. We recommend the method described as being useful in the consulting office.

Introduction

We believe there is a degree of inaccuracy in the usual methods of evaluation of range at the hip in the sagittal plane, ie, flexion-extension [1]. One author suggests hip flexion is limited by contact between the thigh and the abdomen [4]. This is obviously erroneous and refers to

thigh flexion on the trunk, which is a combination of hip and lumbar flexion. Range of flexion of the hip is variably much less than that of the thigh. Thomas's test [5], if conducted by flexing the contralateral hip until the thigh touches the abdomen, is similarly inaccurate as a measure of hip flexion because it includes lumbar spine flexion as well (Fig. 1).

We describe a method of measuring hip flexion and extension and supplement this with some remarks cogent to the straight-leg-raising test.

Background for Proposed Method

Hip ranges of motion are measured from the anatomic position of the pelvis, which we regard as being its posture when a normal individual stands relaxed and with the feet pointing forwards; when standing thus, pelvic mobility is afforded by the lumbar spine, which allows a range of sagittal rotation around an axis joining the centers of the hips. In the anatomic position of the pelvis and in a normal individual, the upper, anterior aspect of the pubic symphysis is in the same vertical plane as the anterior superior iliac spines [4]. If a person stands against a vertical pole (Fig. 2), the most prominent areas over the lower sacrum and the thoracic kyphosis will touch the pole. The posture of the pelvis, which is in the anatomic position, leads to lumbar lordosis, allowing for a convenient space of a flat hand thickness.

If the same patient lies supine and relaxed on a firm couch, the examiner will experience a similar degree of lumbar lordosis with the hand between it and the couch surface, whereby we assume, in the relaxed supine posture, the pelvis is in the same sagittal posture as in the anatomic position. This assumption is crucial to the rest of our

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Fig. 1 A wood engraving shows Hugh Owen Thomas demonstrating his test [5].

discussion: the posture of the supine pelvis defines the neutral position of the hip from which all directions of motion are to be measured. Obviously, although the buttock thickness is compressed, in a very fat or muscular individual in the supine posture, the most prominent part of the lower sacrum will tend to be lifted from the couch. In most cases, however, the spread of the compressed soft tissues allows the lower sacrum to be near the couch surface and the examiner can sense the position of the lower lumbar spine sensitively with the fingertips level with the upper sacrum; this is accomplished in the now usual manner of performing Thomas's test.

When the patient lies prone, the posture of the pelvis is considerably altered with respect to its anatomic position in relation to the couch plane: the pubic symphysis presses on the couch, and because of the forward protuberance of the chest, the anterior superior iliac spines are lifted from the couch by a substantial distance depending on the build of the patient. The pelvis is obviously rotated in the sagittal

plane. Some of the effect imposed by the chest may be taken up by extension of the lumbar spine, but this does not alter the fact that the pelvis is flexed to some degree with respect to the anatomic position: because the thighs lie horizontally on the couch, the hips must be extended by about the same amount as the pelvis is flexed.

A common method of measuring extension at the hip is to put the patient into the prone position and then lift the thigh, often with the knee flexed, while pressing on the lumbosacral area [1]. This method is inaccurate with respect to the anatomic posture of the pelvis and underestimates the true range of extension of the hip by however much the pelvis has been flexed on the lumbar spine.

We suggest an alternative method of measuring hip flexion and extension (Figs. 3–5). To measure flexion of the right hip and extension of the left hip, the patient lies supine with the examiner's hand under the lower lumbar spine thereby palpating the lumbosacral junction from which flexion-extension of the pelvis can be easily detected. Should there be any fixed flexion of either hip, one thigh or both thighs must be flexed sufficiently to allow the pelvis to come into the anatomic position relative to the couch surface. Similarly, a fixed deformity of the lumbar spine would also alter the pelvic posture. We found, however, once the lumbosacral junction had a normal "feel" with respect to the couch surface, invariably the pelvis came to lie in a neutral position; this could be shown by laying a straight edge across the pubic symphysis and the anterior iliac spine. The right hip, with the knee flexed, is flexed progressively until the pelvis is just felt to start rotating as felt by the hand under the lowest part of the lumbar spine (Fig. 4). The right hip is now in a position of true, full flexion as estimated from the angle of the thigh with the couch surface. If the right thigh is flexed further, the pelvis will immediately be felt to rotate progressively; pressure on the examining hand will become greater and a point is reached when the thigh contacts the abdomen (Fig. 5). The difference between the position when the lumbar spine begins to press on the examiner's hand and when the thigh reaches its maximum flexion is the segment of flexion of the thigh contributed by lumbar flexion. At the point of limitation of true right hip flexion, any further flexion of the thigh must entail rotation of the pelvis: this means the left hip will be extending so long as the left thigh remains lying on the couch surface (Fig. 6). Eventually an end point will be reached when extension of the left hip becomes exhausted and then the left thigh will begin to rise. The difference between the angle of the left thigh at maximum true hip flexion and its angle when the left thigh just begins to lift is the range of extension of the left hip.

While the previous discussion relates to the hip, there is a connection between the straight-leg-raising test [3] and the range of hip flexion. This clinical test is usually used to

Fig. 2 The patient stands against a vertical pole, which touches the lower sacrum and the thoracic kyphosis; the separation from the lumbar lordosis contour allows a good handbreadth of space.

Fig. 3 The patient lies supine with the examiner's hand under the lower lumbar spine (shown exaggerated) so as to detect any movement of the pelvis. Should there be any fixed flexion of either hip, that thigh must be flexed sufficiently to allow the pelvis to come into the anatomic position relative to the couch surface.

detect nerve root entrapment by a disk bulge. However, it is commonly performed crudely; the note sometimes seen of "90, 90" may be accurate, but if so, it contains more information than just absence of nerve root compression.

In a normal individual, when the lower limb is flexed at the hip and the knee extended, the range is limited by musculofascial tension from structures at the back of the thigh. If the anatomic position of the pelvis is taken as the

Fig. 4 The right hip, with the knee flexed, is flexed progressively until the pelvis is just felt to start rotating. The right hip is now in a position of true, full flexion as estimated from the angle of the thigh with the couch surface.

Fig. 5 If the right thigh is flexed further, the pelvis will immediately be felt to rotate progressively; pressure on the examining hand will become greater and a point is reached when the thigh contacts the abdomen. The difference between the position when the lumbar spine begins to press on the examiner's hand and when the thigh reaches its maximum flexion is the segment of flexion of the thigh contributed by lumbar flexion.

datum, its position can be judged by the examiner's hand under the lumbar lordosis as already described. When the straight-leg raise is commenced, only the hip rotates and the musculofascial elements begin to tighten (Fig. 7). At some point, the tension in these will develop sufficiently to start to flex the pelvis as well, so that the lumbar spine also flexes; as in detecting the limit of true hip flexion described

Fig. 6 At the point of limitation of true right hip flexion, any further flexion of the thigh must entail rotation of the pelvis: this means the left hip will be extending so long as the left thigh remains lying on the couch surface. Eventually an end point will be reached when extension of the left hip becomes exhausted and then the left thigh will begin to rise. The difference between the angle of the left thigh at maximum true hip flexion and its angle when the left thigh just begins to lift is the range of extension of the left hip.

Fig. 7 Right straight-leg raise is made to the point when the pelvis starts to rotate onto the examiner's hand. Before this occurs, pain only from nerve tension may be detected.

above, this can be felt by the hand under the lumbar lordosis as a definite end point. Up to this point, we presume only the nerve roots will be tightening; if pain is produced, this suggests some nerve root is compressed or there is an inflamed dural sheath at its anchoring foraminal ligaments that is being disturbed. If the straight-leg raise is continued beyond the limit of tightening of posterior thigh musculo-fascial elements, this further segment of raise (Fig. 8) is accompanied by rotation of the pelvis and flexion of the lumbar spine, both of which can be clearly assessed by the

Fig. 8 Right straight-leg raise further than in Figure 7 makes the lumbar spine flex; thus, any local cause for pain emanating from the spine may be distinguished from nerve tension pain.

examining hand. In the absence of radicular pain, pain will be due to movement somewhere in the lumbar spine, indicating a mechanical cause associated with an intervertebral joint. Therefore, the straight-leg raise should always be conducted with the examiner's hand assessing the threshold of pelvic movement. This threshold is entirely different from that imposed when the hip is flexed with the knee flexed. The concepts nonetheless relate.

Using the techniques described above, we measured the true ranges of hip flexion and extension and the range of straight-leg raising in a series of 200 hips.

Materials and Methods

We invited 200 swimmers at the university pool to allow measurement of their left hip ranges of motion and range of straight-leg raising, using the techniques described. Each subject lay on a firm couch and we (RAE, GRA) estimated ranges of motion using a goniometer.

Results

The ranges of hip flexion and extension measured using the described technique were 80° to 140° and 5° to 40°, respectively (Table 1).

Our measurements for ranges of straight-leg raising were 30° to 90° before spine flexion and 50° to 90° or more including spine flexion (Table 1).

Table 1. Demographic data and results of measurements of ranges of hip flexion-extension and ranges of straight-leg-raising

Variable	Measurement
Number of hips	200
Mean age (years)	28* (median, 34; range, 19–89)
Gender (male/female)	104/96*
Range of true hip flexion	80°–140° (mean, 85°; mode, 110°)
Range of extension	5°–40° (mean, 25°; mode, 20°)
Range of straight-leg raising (before spine flexion)	30°–90° (mean, 70°; mode, 67°)
Range of straight-leg-raising (including spine flexion)	50° to $\geq 90^\circ$ (mean, 86°; mode, $\geq 90^\circ$)

* No significant differences in ranges measured were found.

Discussion

Conventional methods for measuring ranges of motion around the hip are ingrained in orthopaedic practice. We find the techniques described simple to perform and comfortable for a patient. We emphasize the measurements are made with the pelvis in a neutral posture and note the wide variation between individuals. We found no similar data in the literature. Some orthopaedic surgeons might choose to use another reference in which the pelvis is flexed so as to obliterate the lumbar lordosis: we suggest this puts the pelvis into an abnormal position with regard to that from which the hips normally function.

Whatever method for measurement may be used, anatomic variations can make this uncertain. Examples are obesity, augmented thoracic kyphosis, and reduced or increased mobile or fixed lumbar lordosis. We find, by using the method described, such difficulties can be overcome if it is ensured the pelvis is in a neutral position, as judged by the hand palpating the lumbosacral junction. Thus, the patient may have to be correctly positioned by elevating the upper flap of the examination couch to achieve this; the horizontal posture of the pelvis can be checked by identifying the pubis and the anterior superior iliac spines, but in most cases it is the hand under the lumbosacral spine that is sufficiently sensitive to achieve the posture required.

We do not suggest merely changing the technique of examination from a more conventional estimation of hip extension (lying prone) will introduce substantial change in hip surgical practice, but the technique has other potential applications, for example, in calculations for a corrective osteotomy where restoration of normal extension range for that individual hip should be the aim. Thus while the modal

extension was 20° (an amount that might be obtained from other methods of measurement), we found a range of 5° to an exceptional 40°: in a unilateral osteotomy, it would seem correct to restore range of extension to that of the opposite side. Other potential applications include detection of early loss of extension in some cases of hip pain by comparison with an opposite normal side and early arthrosis or other intrajoint cause as in the difficult case of hip pain that is not accompanied by obvious radiographic change.

The increased accuracy we believe afforded by our proposed method is unlikely to influence hip replacement technique. Sophisticated imaging techniques are now well described [2], and these can augment accuracy and information; however, the range of motion of the hip has still to be measured clinically—essentially an office procedure.

Isolated flexion of the hip detects pain from the hip itself. When this range is exceeded (ie, becomes thigh flexion that involves the spine) and the pelvis and a possibly sensitive lumbar spine are disturbed, in some instances such pain could emanate from the lumbar spine and yet be confused with less usual posterior hip pain.

We contend, when the straight-leg-raising test is performed with an examining hand under the lumbar lordosis identifying the posture of the pelvis and sensing any movement of this, there is a means of distinguishing nerve root tension pain from mechanical back pain. If the cause of lumbar back pain is due to mechanics (ie, not associated with nerve root pathology), exceeding the limits of true flexion of the hip and straight-leg raise will both produce pain when either disturbs the pelvis and thereby flexes the irritable lumbar spine. If pain is produced during straight-leg raise before pelvic disturbance, this will relate to nerve root tension. If the patient has increased pain during the true range of hip flexion (ie, with the knee flexed and before the pelvis is disturbed), there must be some other explanation.

An essential point is that all of these examinations relating to the hip and the lumbar spine in the sagittal plane must be performed with the examiner's hand assessing the pelvic position and any movement that may be transmitted to the lumbar spine.

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