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DETERMINATION OF THE SAGITTAL MOBILITY OF THE LUMBAR SPINE

A Clinical Method

By

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An important component of any examination of the orthopaedic patient is an assessment of the mobility in the various joints, and numerical values for the ranges feature prominently in reports of the orthopaedic status. As regards the lumbar spine the following mensuration methods are to be found in the orthopaedic literature.

I. Measurement, in the erect posture, of changes in angle between the thoracic spine and the vertical.

II. An estimate of the distance between two or more spinous processes.

III. Measurement of the distance from the finger-tips to the floor in maximum flexion.

IV. Estimation of the difference in the contour of the spinal column between two extreme positions.

V. Registration of this difference.

VI. Measurment of angular changes between individual vertebrae on a lateral radiograph.

I. Measurement of changes in the angle between the thoracic spine and the vertical line is probably the method that has been most frequently recommended for clinical work. Figure 1 shows the technique given in the Manual of Orthopaedic Surgery of the American Orthopaedic Association (11). The same recommendation is found in the special edition of J.A.M.A. for joint examination (21) as in several standard works on orthopaedic examination technique (8, 12, 13). The range of movement is given in J.A.M.A. as 120° (21).

II. Estimation of the distance between two or more spinal processes

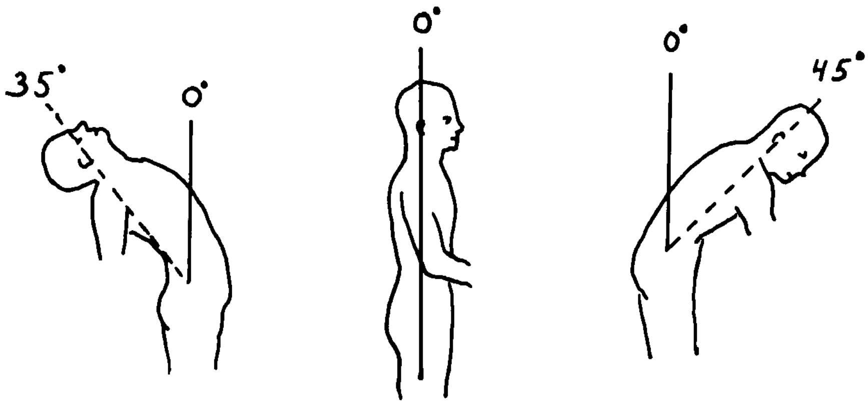

Figure 1. Measurement of spinal mobility, according to the American Orthopaedic Association.

is often recommended (5, 8, 16, 17), but as a rule no accurate technique is given, nor have any normal values been reported.

III. Measurement of the smallest distance between the finger-tips and the floor is sometimes recommended (1, 5, 11), but this can give only an impression of the magnitude of flexion. The values vary from —10 to +50 cm, and normal values are difficult to find.

IV. Estimation of the shape of the back (lordosis, kyphosis) by eye is often recommended (1, 5, 7, 15, 19) because the mobility of the hip cannot be excluded during flexion.

V. Drawing or photographic recording of the sagittal contour or application of a pliable plastic ruler along the spinal contour in the two extreme positions is sometimes recommended (6, 22). The range of mobility can then be seen as the differences in the shapes of the curves in the two positions, and it is possible to express the angles between the different positions of the curves (22).

VI. Measurement of the mobility of two vertebrae in relation to one another can be performed most accurately on radiographs, and by combining the ranges of mobility of several disks one can obtain the total range of movement for a particular section of the column. A number of authors have described such methods (3, 4, 9, 20, 23, 24). The values for the mobility of the lumbar spine have been reported as 30–121°, usually 65–80°.

COMMENTS

On the methods mentioned here it is probably only the contour method (V) and the measurement on radiographs (VI) that meet reasonable

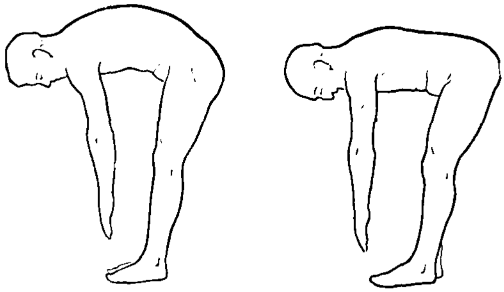

*Figure 2. Estimation of the range of mobility of the lumbar spine by examination of the varying contour (*Adams *(1)).*

scientific demands on exactness. The usual method of measuring the range of mobility—by the change in angle of the thoracic spine—implies an indefensibly large and didactically unacceptable source of error, namely the included movement of the hip-joints. It is surprising that in spite of this obvious source of error the method is still commonly advocated. Many authors of textbooks have, however, discussed this error and pointed out the need to ensure that it is the movement in the actual spine that is being measured (Figure 2). Estimation of the change in spinal contour is recommended instead (*Adams* (1)).

The leg-raising test or Lasegue's sign is used as a test of the degree of irritation of the sciatic nerve or its roots. The test of spinal mobility in the erect posture can be said to be a "standing leg-raising test", which may be of interest in another context. For some patients the test is negative in the supine position but positive erect. The reason for this is not clear, but it would seem natural to suppose that in the standing position the nerve roots may be subjected to compression (via normal or herniated disks). This way of testing spinal mobility is thus informative as to spinal function but does not disclose the mobility of the lumbar spine. Many authors have pointed out that the mobility of the back should be examined in the erect posture with the knees extended, but *Perkins* (19), for instance, prefers the seated position in which "the hamstrings and the sciatic nerve are all lax". Measurement of the distance between the finger-tips and the floor can be of some value when it is required to follow the status of a particular patient over a long period, but this distance does not constitute a measure of spinal mobility that will serve for comparison of patients, or even for judging whether the range of mobility is normal.

The registration of the sagittal contour of the spine (by means of a flexible ruler, shadow tracing or photography) in maximum extension

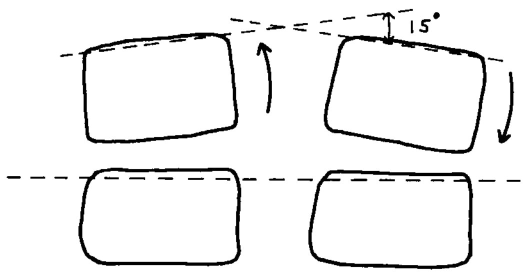

Figure 3. Determination of the sagittal range of mobility in two adjacent lumbar vertebrae.

and flexion provides a fairly accurate record of the range of the spinal mobility. One disadvantage of the method is that the recording is time-consuming, another that it is difficult to derive comparable numerical values from the curves. It is true that one can measure the angle between L_1 and the sacrum in ventroflexion and dorsal extension, but this does not give the range of movement of the intervening disks (see below *Mechanics of spinal mobility* and Figure 5).

The most exact impression of the range of mobility is obtained by measurements on radiographs, and the only significant source of error lies in the difficulty of obtaining the full range of mobility because of pain or discomfort and the inexactness of the terminal positions. The registration itself is exact.

Mechanics of Spinal Mobility

To determine the range of mobility of a joint it is common to measure the change in the angle between the longitudinal axes of the two bones containing the joint. The movement of a disk is certainly more complex than that in an ordinary hinge joint, and sometimes involves not only a change in angle but also a translation and a displacement of the centre of motion during the movement (14). Still, the chief component of the movement is an angular change and there is no difficulty in measuring such a change in angle on the radiograph (Figure 3). The numerical value obtained for the change in angle is the same, whether the upper or lower surfaces or the anterior border of the vertebrae are used as refence lines.

The lumbar spine as a unit consists of 5 such joints, and it is the total mobility of these that is to be measured. Although this total mobility

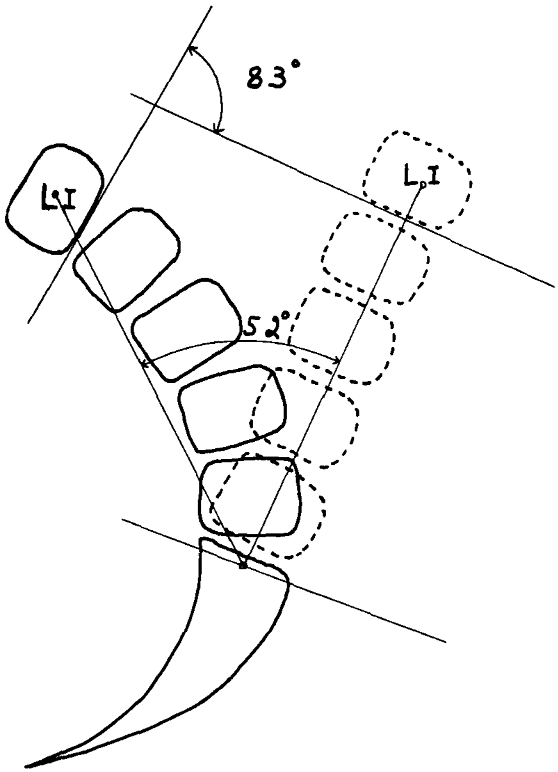

Figure 4. Determination of the sagittal range of mobility in the whole lumbar spine (5 disks). Change in angle of the first lumbar vertebra between two extreme positions (83°) corresponds to the sum of all the changes in angle for the individual disks. The angle formed between L_1 and the sacrum in the two extreme positions (52°) will always be less than the preceding angle.

involves a considerable forward and backward displacement of the whole spine, there is still an angular change between the upper vertebra L_1 in relation to the sacrum in maximum extension and flexion (Figure 4). The angular change of the uppermost vertebra in relation to the sacrum is then as great as the sum of all the angular changes in the individual joints. Hence, if the whole lumbar spine is considered as a single joint (albeit a long one), its range of mobility can be measured exactly in degrees. A similar procedure is used in measuring the range of mobility of other joints, such as the wrist, which consists of 3 joints.

The angle formed by the two lines joining the sacrum and the middle of the first lumbar vertebra, one in full flexion and the other in full extension, is likewise a kind of measure of the range of spinal mobility.

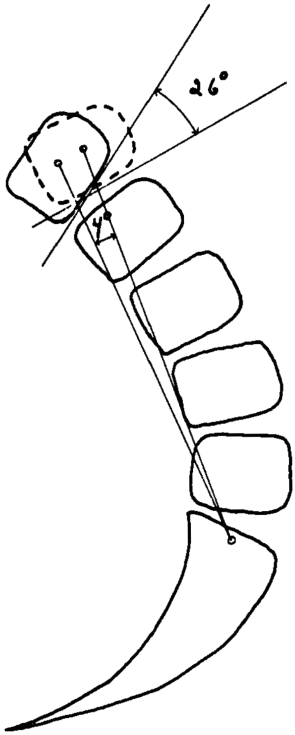

Figure 5. When the change in the L_1—sacrum angle in movements is used, the angle reading obtained for a given angular change diminishes the further the movement occurs from the sacrum.

This angle, however, does not bear any mathematical relationship to the above-mentioned angle (the sum of angular changes in the 5 disks), but is dependent primarily on the length of the lumbar spine. An angular change between the upper vertebrae will give a smaller reading for the L_1—sacrum angle than the corresponding change in the angle between the lower vertebra and the sacrum (Figure 5).

A New Clinical Method for Measuring the Sagittal Mobility of the Lumbar Spine

A new method for measuring the total sagittal range of mobility of the hip-joint has been evolved by *Ahlbäck & Lindahl* (2). In earlier methods for finding the sagittal mobility of the hip the value obtained has included part of the spinal mobility. As this component can be eliminated by the new method, the study was extended to include the

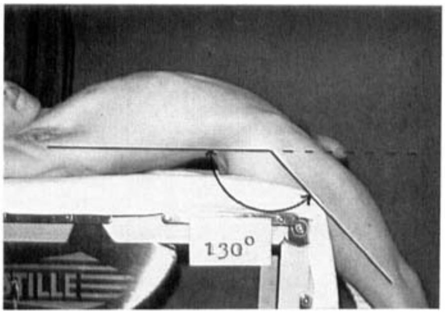

Figure 6 A. The initial position in measurement of the sagittal range of mobility of the hip and lumbar spine. In this position the angle between the thoracic spine and the thigh in full extension of both the lumbar spine and the hips is also determined.

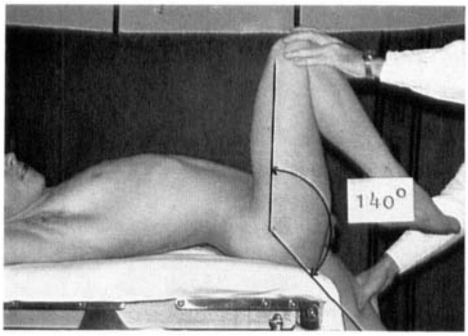

Figure 6 B. The range of mobility of the thigh to this position corresponds to the total sagittal mobility of the hip-joint. The pelvis and spine are kept in a fixed position by the lowered thigh.

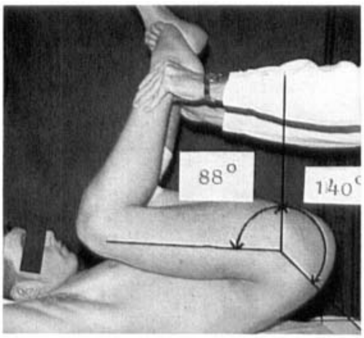

Figure 6 C. Here the combined range of mobility of the spine and hips is attained.

combined mobility of hip and lumbar spine. By subtracting the sagittal mobility of the hip from the total, the mobility of the lumbar spine was obtained. The procedure can be applied to both hip-joints, thus providing a check of the accuracy.

The examination was performed with the patient lying supine on a table over the end of which his legs hung from the hips. The thighs were lowered until lumbar spine and hips were fully extended (Figure

6 A). In this position the pelvis and lumbar spine were locked by preventing movement of one thigh. The other was flexed fully in the hip-joint until a resilient resistance was felt (Figure 6 B). This part of the movement of the thigh constitutes a determination of the sagittal mobility of the hip (*Ahlbäck & Lindahl* (2)). The fixed thigh was then released and the flexion of the other thigh was continued up to the trunk, the lumbar spine being thereby kyphosed or flexed (Figure 6 C). For persons with an exceptional spinal mobility or a large stomach closer attention and sometimes a special technique are called for. If the extension of the lumbar spine is great the table must be quite high, since the legs then may need to be almost at right angles to the thoracic spine. In flexion the abdomen may sometimes be encountered before the terminal position is reached. The thigh must then be flexed past the trunk, and in the case of extreme mobility it may even be necessary to continue the movement beyond the table. When full flexion is being performed it must be ensured that the lumbar spine is not rolled up so much that the lower part of the thoracic spine is also raised from the table. When this precaution is being taken, too, there is a small movement between the lower thoracic vertebrae, as can be seen on the radiograph, and this movement will be included in the measured mobility.

In this way one can measure the change in angle of the femur first with one thigh fixed (range of mobility of the hip-joint) and then with this thigh released (range of mobility of the lumbar spine). With the angle-measuring device recommended by *Ahlbäck & Lindahl* (2) it is then possible to obtain a measure of the mobility of the hip and a measure of the combined mobility of the hip and lumbar spine. The mobility of the lumbar spine is then obtained by subtraction.

The examination can be repeated on the other side, and whether the ranges of mobility of the two hip-joints are the same or different, two values of the residual range of lumbar spine mobility are obtained. The agreement between these values provides a check of the accuracy of the examination. From the theoretical standpoint the values shall be equal, but in practice they sometimes differ by up to 10–15° because the end positions for the movements are not exact, but are dependent on how strongly the joints are strained during this manipulation. If, in addition, the movements cause pain in one or both hip-joints or the spine, it will be even more difficult to obtain identical terminal positions.

Because full extension and flexion are seldom, if ever, performed by ordinary people, extension, in particular, will sometimes cause discomfort; but if the movement is made slowly and carefully by gradually lowering of the legs, the examination can usually be performed satisfactorily. In persons suffering from back pains these difficulties are accentuated and it is sometimes impossible to complete the movement. This, however, is a limitation that the method shares with all examinations of painful joints, and where pain is being caused, a determination of the range of movement will invariably involve a compromise between the tolerance of the patient and the insistance of the examiner.

Apart from the range of mobility of the lumbar spine, it is possible in this examination to record the angle between the thoracic spine or horizontal plane and one or both thighs in full extension of both lumbar spine and hip-joints (Figure 6 A). This value is of practical interest chiefly in the pre-operative examination of a patient who is to be provided with a hip arthrodesis. In determining the flexion angle that is suitable for the arthrodesis, a knowledge of these angles for both thighs is of the greatest interest (*Lindahl* (18)).

DISCUSSION

In practice it is rarely necessary to determine the exact range of mobility of the lumbar spine. This is suggested by the fact that the above clinical methods have been relied on for so long. The more accurate radiographic methods have only been used in connection with scientific studies. In the examination of a patient with back disorders, and to make a diagnosis, a rough estimate of any restriction of mobility will usually suffice. An assessment of spinal mobility in such terms as normal, slightly or considerably reduced, or completely eliminated is then preferable to numerical data in degrees or centimetres.

With the availability of a simple clinical method the need for more accurate data on the mobility range may well increase. In particular such data can be of interest in connection with insurance. For scientific use, as for instance in judging the results of a certain form of treatment for a back disorder, a more accurate method may also be desirable, and in the determination of the position for a hip arthrodesis this technique would seem to be indispensable if the best functional position of the joint is to be found (18).

Range of Lumbar Spine Mobility Measured by the New Method

In 58 patients with various diseases but no back disorders the range of mobility of the lumbar spine was examined by the method described above. Although these subjects were not a randomized sample of a normal population they do represent an age range. The measurements showed, as expected, that the mobility diminished with age and that there were extremely large individual variations (Table 1). The examinations were performed on both legs. The differences between the two values so obtained are given in Table 2, and constitute a measure of accuracy of the determination. The angle-measuring device enabled readings to be made to the nearest degree. The method itself was not so accurate as this, of course, but nothing would probably have been gained by approximating the original values.

Table 1. Sagittal range of mobility of the lumbar spine in normal subjects distributed with respect to age.

Age	20–29	30–39	40–49	50–59	60–69	>70
No. of cases	10	8	11	10	12	7
Mean	89	82	76	66	59	48
Range	61–105	55–99	50–93	51–82	40–72	31–79

Table 2. Difference between the two values for the sagittal mobility of the lumbar spine.

Difference (°)	0	1–4	5–9	10–14	>15
No. of subjects	10	34	31	10	3

Table 3. Thoracic spine—femur angle for normal subjects with full extension in both lumbar spine and hips, distributed with respect to age.

Age	20–29	30–39	40–49	50–59	60–69	>70
No. of cases	10	8	11	10	12	7
Mean	130	139	144	146	149	154
Range	111–140	118–148	128–159	125–162	134–168	131–174

The angles between the thoracic spine and the thighs in full extension of both hip-joints and lumbar spine are given in Table 3 (Figure 6 A). As in the case of the lumbar spine mobility, this angle diminished with age.

DISCUSSION

For the mobility of the lumbar spine J.A.M.A. (21) reports a value of 120°. This is obviously too high, and relates to the combined, but not total, mobility of the lumbar spine and hip. *Fick* (10) gives 113° for a specimen, *Åkerblom* (24) a mean of 73° for 3 specimens. For measurements on radiographs of living subjects values of 30–83° have been reported (3, 4, 9, 20). *Wiles* (23) obtained values of 115 and 121° for two acrobats. The values given by the present method are in close agreement with those obtained by radiography on normal subjects. It is possible that the values obtained here—at least at the lower ages—were slightly higher. This is probably due to the inclusion of part of the mobility of the lowermost thoracic vertebrae. Since this part of the thoracic spine is from a functional standpoint associated more closely with the lumbar spine than with the thorax, this is not a disadvantage. In their radiographic determinations *Bakke* (4) and *Schalimtzek* (20) measured forward and backward flexion from a mean or zero position, which however they do not define closely. Although the mean total range of mobility was much the same for the two authors, *Bakke* obtained only 14° in forward flexion against *Schalimtzek's* 29°, a discrepancy that may well have been due to the difficulty of defining and determining a mean position. The position assumed spontaneously by the lumbar spine differs in the erect and seated positions and is affected in the erect posture by a number of factors, such as bearing, need for a change of position and back fatigue. For this reason no such supposed mean position was determined in the present study.

The range of lumbar spine mobility was examined also in some 50 cases of back disorders. In these cases the mobility was of course much reduced owing to pain and the pathological conditions. The ranges are given in Table 4.

Table 4. The sagittal range of mobility for cases of back disorders.

	No. of cases	Mean	Range
Ankylosing spondylitis (Bechterew's disease)	6	12	5–21
Lumbago, acute	8	16	5–27
Lumbago, chronic (+ degen. disks)	19	35	21–65
Dorsal insufficiency	21	55	29–82

SUMMARY

With the exception of measurements on radiographs the various methods reported in the literature for determining the sagittal mobility of the lumbar spine have various disadvantages, and these are discussed. A new clinical method of measurement is presented which is based on one published earlier by *Ahlbäck & Lindahl* for measuring the sagittal mobility of the hip-joint. The mobility of the lumbar spine is obtained by subtracting the mobility of the hip from the combined mobility of the hip-joint and lumbar spine. With this method, which gives values in close agreement with those obtained from radiographic measurements, an examination was made of 58 sound backs. The mobility decreased with age. For the age range 20–29 years the mean was 89°, and for the group above 70 years it was 48°.

RESUME

A l'exception des mensurations sur les radiographies, les différentes méthodes rapportées dans la littérature pour déterminer la mobilité sagittale de la colonne lombaire ont différents désadvantages qui sont discutés. Une nouvelle méthode clinique de mensuration est présentée sur la base d'une méthode publiée antérieurement par *Ahlbäck & Lindahl* pour mesurer la mobilité sagittale de l'articulation de la hanche. La mobilité de la colonne lombaire est obtenue en soustrayant la mobilité de la hanche de la mobilité combinée de l'articulation de la hanche et de la colonne lombaire. Avec cette méthode qui fournit des données extrêmement conformes à celles obtenues par les mensurations radiographiques, il a été procédé à l'examen de 58 dos sains. La mobilité décroît avec l'âge. Entre 20 et 29 ans, son étendue moyenne a été de 89° et pour le groupe de plus de 70 ans, elle a été de 48°.

ZUSAMMENFASSUNG

Mit Ausnahme von Messungen an Röntgenbildern haben die verschiedenen in der Literatur beschriebenen Methoden zur Bestimmung der sagittalen Beweglichkeit der Lendenwirbelsäule verschiedene Nachteile. Diese werden besprochen. Eine neue klinische Messungsmethode wird aufgezeigt, die zur Grundlage eine Methode der Messung der sagittalen Beweglichkeit des Hüftgelenkes hat, die früher von *Ahlbäck & Lindahl* veröffentlicht wurde. Die Beweglichkeit der Lendenwirbelsäule wird mittels Subtraktion der Hüftbeweglichkeit von der Gesamt-

beweglichkeit des Hüftgelenkes und der Lendenwirbelsäule erhalten. Mit dieser Methode, die Werte in enger Übereinstimmung mit denen, die man bei röntgenologischer Messung findet, ergiebt, wurde eine Untersuchung an 58 gesunden Rücken vorgenommen. Die Beweglichkeit nahm mit zunehmendem Alter ab. Für den Altersbereich von 20–29 Jahren war der Umfang 89°, und für die Gruppe über 70 Jahre war er 48°.

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