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SAGITTAL MOBILITY OF THE HIP-JOINT

By

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The sagittal range of mobility of the hip is defined for the purpose of this study as the angular difference in maximum extension and flexion. This range of mobility will be referred to below as *total flexion.* Whereas it is usual to specify the flexion and extension of the joint separately, in this study it is assumed that the total flexion is the sum of these two components. *Milch* (5) points out that the common methods of measuring the flexion of the hip-joint do not take account of the simultaneous mobility of the pelvis, and that the values so obtained may therefore be misleading. He suggests that instead of using the table or horizontal plane as the reference line, a more accurate measure is provided by the difference in the angle formed by the axis of the shaft of the femur and Nélaton's line (the pelvi-femoral angle) in maximum flexion and extension. *Milch* found this angle to be 50° in the normal subject with the hip-joint fully extended; in maximum flexion this angle will be about 125°, giving a total flexion of about 75°.

Milch's values contrast with those given in the usual textbooks, which range from 130–140°.

	Flexion	Extension	Total flexion
Milch (5)			75
Fick (2)	121	13	134
Lantz & Wachsmuth (4)	120	15	135
Chapchal (1)	110 (120*)	20	130 (140*)
Ama (7)	100	30	130
Howorth (3)	120	20	140

These authors measured flexion in the supine position and extension in the prone position. In Thomas' method for measuring the flexion contracture it was prescribed that lumbar lordosis should be obliterated.

1 Radiologist. 2 Orthopaedic surgeon. * Passive movements.

It is not indicated whether this should apply also in the measurement of flexion and extension and details of the technique are often lacking.

To explore the reasons for the discrepancies between the reported values for the range of mobility of the hip-joint, and to study the movement of the pelvis in an examination of this joint, a series of examinations of the mobility of the hip-joint were performed; this was determined by various clinical methods and by radiography. From these studies a new clinical method for determining the total flexion of the hip was developed.

MATERIAL AND METHODS

The study was performed using 95 subjects with normal hips and on 10 cases of osteoarthritis.

Thomas' Method.

Flexion: The patient was placed in the supine position. The angle formed by the longitudinal axis of the thigh and the table was determined after flexion of the thigh up to the abdomen, or, if it would not close up to the abdomen, until the lumbar lordosis was apparently eliminated. During this movement the other leg was kept in contact with the table or permitted to follow into a flexion position (Fig. 1 A).

Extension: Patient in the prone position. The angle between the longitudinal axis of the thigh and the table was determined by lifting the leg until a moderate resistance was encountered, and with the pelvis maintaining contact with the table (Fig. 1 B). The other leg remained on the table.

Flexion contracture: The hip not under examination was flexed up to the abdomen or, if resistance was encountered earlier, until the lumbar lordosis was apparently eliminated. The angle between the axis of the thigh under examination and the table was determined (Fig. 1 C).

When there was a flexion contracture this was subtracted from the flexion mobility to give the flexion of the hip-joint; in these cases no examination of extension was made.

Milch's Method.

The patient was examined in the lateral position with the examined leg uppermost. The hip was extended fully, with an increase in the lumbar lordosis, and in this position the axis of the femur was drawn on the skin, as was Nélaton's line (spina iliaca anterior superior—tuber

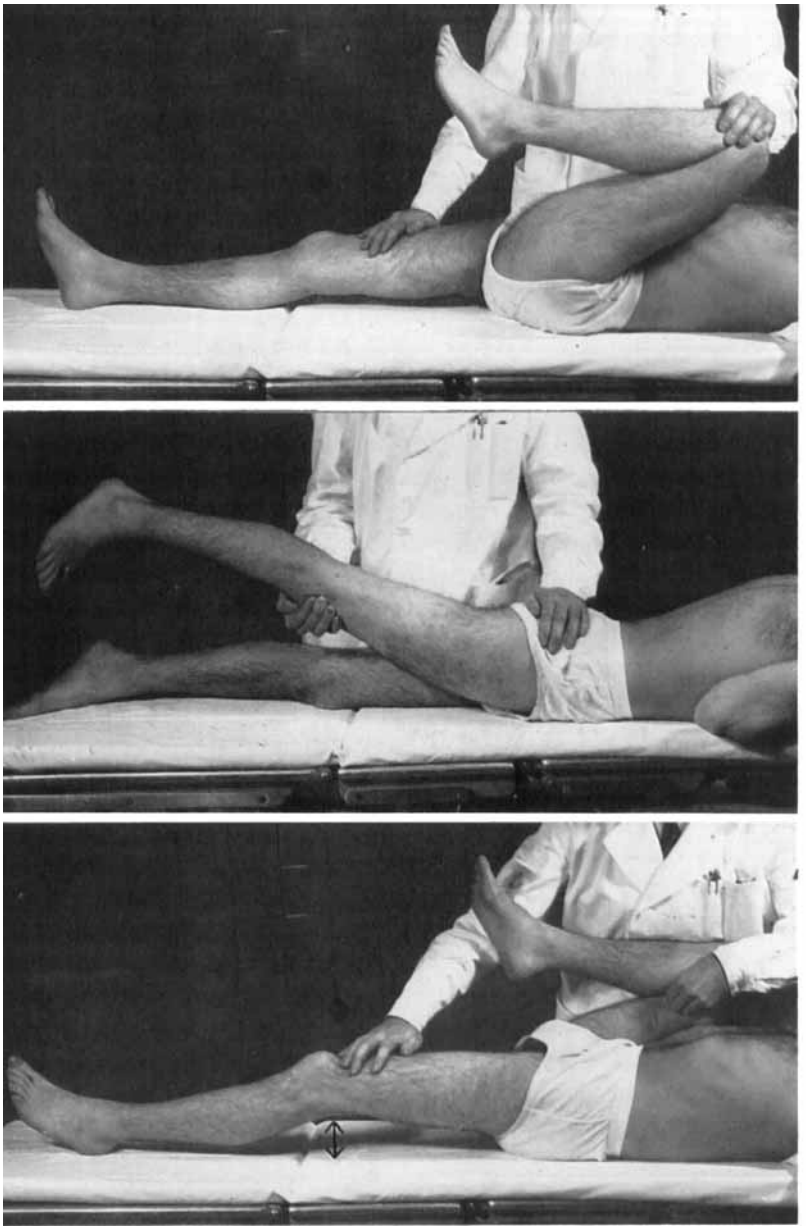

Fig. 1.
Determination of flexion of the hip joint by Thomas' method:
A, flexion; B, extension; C, flexion contracture.

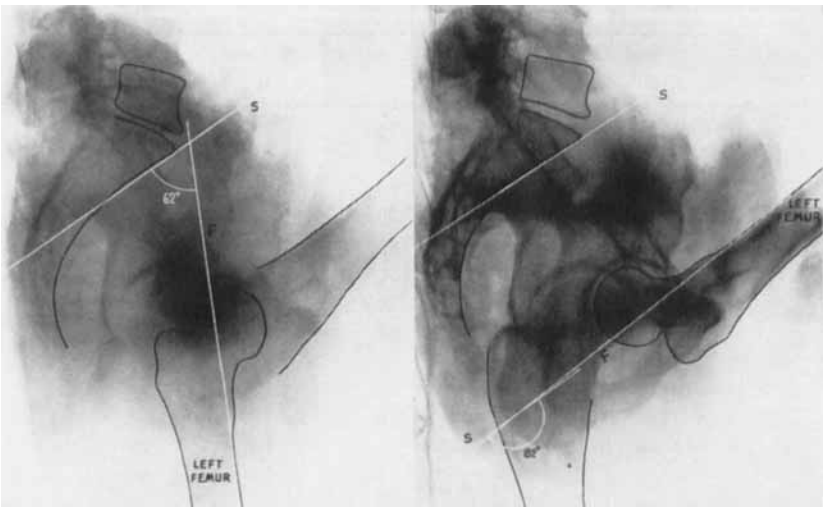

Fig. 2.
Radiographic measurement of total flexion of the left hip-joint.

ischii). The angle between these lines was measured. The same leg was then flexed fully while the other leg was kept straight. The two lines were again drawn on the skin and the angle so formed measured.

Radiographic Measurement.

Lateral projections were used to obtain the angles between the axis of the femur and various reference lines on the pelvis (Fig. 2). The film-focus distance was about 100 cm. The examined leg was nearer the film and the beam was centered on the head of the femur. The upper part of the anterior surface of the sacrum (S) was used as the reference line on the pelvis. Where there was no rotation of the pelvis in any other plane the angles measured on the films were taken as the "true" angles, account being taken of a measurement error of about 3°, which was ascertained by repeating the measurements.

RESULTS

Comparison between Clinical Measurements Obtained by Two Investigators.

Two physiotherapists independently examined 24 hips by the methods of Milch and Thomas. The angles were measured to the nearest 5°.

TABLE 1

Normal subjects	Flexion (Thomas)		Total flexion (Milch)		Pelvo-femoral angle in extension	
	I*	II**	I	II	I	II
1	145	140	75	75	50	50
2	130	140	70	70	50	50
3	140	135	75	75	50	50
4	130	140	70	75	50	45
5	135	130	65	70	45	50
6	130	135	70	65	50	50
7	125	130	70	75	50	50
8	140	150	65	65	50	50
9	150	145	70	70	50	50
10	145	140	70	75	50	50
11	140	150	75	85	50	50
12	150	150	75	70	50	50
13	135	145	75	75	50	50
14	140	145	75	75	50	50
15	125	120	60	40	60	60
16	130	140	85	70	45	50
17	110	100	60	45	50	60
18	140	145	65	65	50	50
19	120	130	60	70	50	50
20	130	150	70	75	50	50
Cases of osteoarthritis						
21	65	60	30	25	60	60
22	80	70	50	50	60	60
23	30	30	20	25	70	80
24	95	70	60	45	55	60

* Investigator I. ** Investigator II.

There was a close agreement between the results obtained by the two investigators, as seen from the following summary of Table 1.

Difference in measurements	0°	5°	10°	15°	20°	25°
Number of comparisons	28	25	14	3	2	0

Thus a difference of 5° or less was obtained in 74 per cent of the measurements.

There was a considerable difference in the flexion values yielded by the two methods.

Difference in flexion between Thomas' & Milch's methods	≤50°	55°	60°	65°	70°	75°	80°	85°
Number of comparisons	10	3	9	8	7	6	4	1

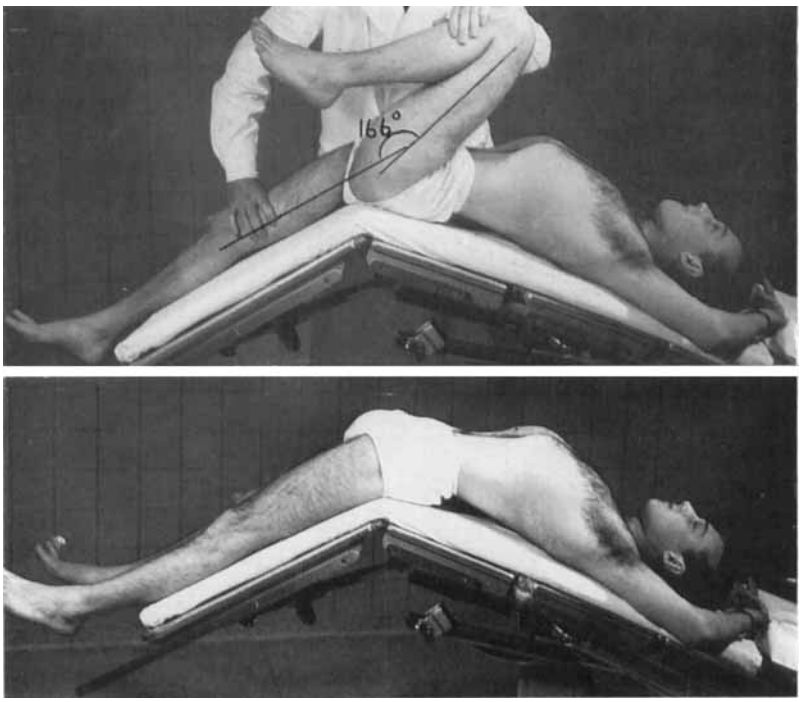

Fig. 3 A.
Determination of total flexion of the hip-joint by the author's method on a table with a dropped end.

On an average, Milch's method for total flexion gave values that were 60° smaller than did Thomas' method for flexion alone. No extension mobility was included in the Thomas' values; the difference would then have been even greater.

Radiographic Examination of Hip-Joint and Pelvis Mobility for Different Positions of the Leg and Trunk.

An analysis of the mobility of the pelvis and hip-joint in different positions of the body performed on 10 subjects gave the following results. The relation between the pelvis and femur differed in the supine and prone positions. The difference in angle ranged from 3° to 15°, the hip-joint usually being flexed more in the prone position. In the supine posture with the leg straight there was a flexion of the hip-joint of 7–22°. In flexion to 90° the movement was restricted almost entirely to the hip-joint, but beyond this the pelvis was also involved. In ex-

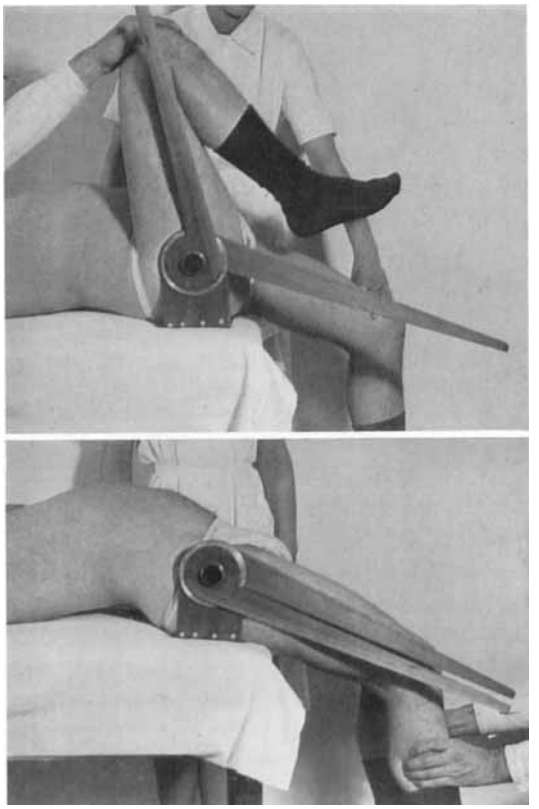

Fig. 3 B.
Determination of total flexion of the hip-joint by the author's method on an ordinary examination couch, using a special device for measuring the angle.

tension the movement took place simultaneously in the pelvis and hip-joint. In the erect position there was a flexion of 9°–25°.

Full extension of the hip-joint could be obtained in two ways:

(i) The leg not being examined could be flexed up to the abdomen (when the pelvis was also flexed), with the other leg still in contact with the table fully extended, or (ii) in the supine position, both legs could be extended 30–60° to the horizontal plane. The latter procedure was necessary where the abdomen was large or the range of mobility was great.

Full flexion was obtained when the examined leg was bent fully and the other leg was kept on the table. If this leg was also flexed up to the abdomen, the pelvis was rotated so that full flexion was lost. In the case of exceptionally great mobility of the hip-joint—and large abdomen—full flexion of the examined leg could sometimes be obtained only on rotating the pelvis by dropping the other leg below the horizontal plane.

A New Method for Determining Total Flexion of the Hip-Joint.

On the basis of the data obtained from this radiographic analysis, a new clinical mensuration technique was developed. The subject is placed in the supine position (i) on a table one end of which could be dropped so as to obtain full extension of the hip-joint (Fig. 3 A), or, (ii) on an ordinary examination couch, but with both legs hanging over the short end (Fig. 3 B). Both legs are then extended fully by dropping them through an angle of 30–60°, whereby the lumbar spine is strongly lordosed. The leg not being examined, and hence the pelvis, are locked in this extended position. The examined leg is then flexed until an elastic resistance is encountered; with this method this will occur some distance from the abdomen. The angular movement of the leg is measured. If the extension differs on the two sides the procedure is in principle the same. If the joint with the smaller range of mobility is examined it should be ensured that the pelvis is locked in extension by extending the leg not being examined more than the other one.

To facilitate the determination of the range of mobility of the hip, a special device for measuring the angle has been designed.[1] When the hip-joint is fully extended one arm of the angle-measuring device, together with the scale, can then be locked parallel to the thigh. The other arm can be set parallel to the thigh, which is flexed. The total flexion of the joint can then be read off on the scale (Fig. 3 B).

Comparison between the Methods.

From Table 2, which shows the values for 22 hip-joints examined, it is seen that there is a close agreement between the new clinical method and the radiographic measurement.

Thomas' method gave too high values. When only the flexion angles obtained by this method were used, the values were slightly on the high side. The method of Milch gave very low values.

Examination of Normal Subjects by the New Method.

Measurements were performed on 7–10 men in each decade between 20 and 80 years and without hip symptoms. The total flexion of the hip-joint showed a large individual variation, with values ranging from 107 to 170°; on an average this mobility decreased with age (Table 3).

[1] AB Stille-Werner, Stockholm.

TABLE 2

Total flexion				Flexion
X-ray	Milch	Authors	Thomas	Thomas
160	–	155	189	162
160	–	160	194	160
136	–	130	152	142
132	–	133	160	138
142	–	155	168	140
140	–	135	170	140
147	–	133	170	142
135	–	132	157	140
140	–	147	195	150
145	–	150	195	150
137	–	137	160	145
120	–	121	145	135
125	–	131	156	140
125	–	134	182	140
133	70	–	155	135
150	100	–	195	170
124	100	–	165	140
147	90	–	185	160
135	75	–	155	135
148	80	–	190	170
120	55	–	175	150
76	45	–	120	120

TABLE 3

Age	20–29	30–29	40–49	50–59	60–69	70–79
No. of subjects	10	8	9	10	9	7
Mean total flexion	161	153	151	136	132	122
Range	141–178	128–165	129–167	115–143	116–141	107–143

DISCUSSION

The differences in the measurements obtained with the methods of Milch and Thomas and reported by previous workers are confirmed by this investigation. However, comparison with the values obtained by radiographic analysis shows that those given by Milch's method are obviously incorrect, in spite of the logical design of the method. The reasons for this probably lie in the difficulty of locating the tuber ischii in extension, of palpating the spina iliaca anterior superior in maximum flexion of the hip-joint and of obtaining full flexion in this position. Thomas' method involving the summation of flexion and extension is

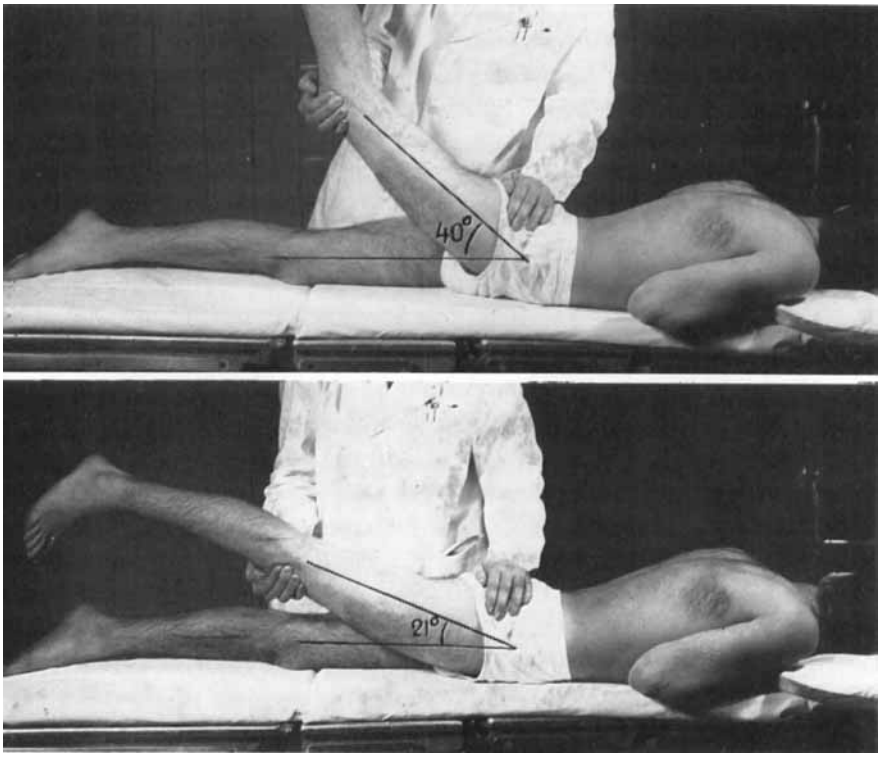

Fig. 4.
Determination of extension by Thomas' method.
The final position is difficult to determine.

likewise unsuitable, since it gives too high values. The reason for this is that the mobility of the pelvis is included in both flexion and extension, and that the reference position from which the measurements are made changes as the patient is turned.

A further source of discrepancy in this method is the uncertainty whether the flexion should be continued until the lumbar lordosis is normal, or straight or perhaps even changed to kyphosis.

The flexion values given by Thomas' method are in close agreement with those obtained by measurements on the radiographs, but this is a pure coincidence and is due to the fact that two opposing errors usually cancel one another out. In the initial position there is already an unknown flexion which is not measured—in the present cases 7–22°. There is then usually a balance of this, or a slightly larger angle, when maximum flexion is performed, since then the rotation of the pelvis is

included. The determination of extension will be extremely arbitrary, because the movement is performed against an elastic resistance (Fig. 4) and because, from the outset, there is a simultaneous movement of the hip-joint and the pelvis.

The new method seems to eliminate all these disadvantages. The pelvis is locked in maximum extension and the examined joint is fully extended. With the pelvis still fixed in extension the hip-joint is then flexed until an elastic resistance is encountered; in this position there is no obstruction from a large abdomen, nor is it necessary to assess the lordosis. The method is fairly easy to apply with the specially designed device for measuring the angle.

How should any flexion contracture in a hip-joint be measured? A flexion contracture may be defined as the angular difference between the normal and the actual extension of the joint. If one hip-joint is considered to be normal—though this may be difficult to judge—the best method of assessing the flexion contracture in the other hip-joint is to compare the extension when both joints are fully extended. This is easily done by dropping the legs below the horizontal and measuring the angular difference in maximum extension. If there is a flexion contracture in both hip-joints, one requires for the measurement of these contractures (i) a normal value for the angular relation between the femur and a suitable reference line on the pelvis, and (ii) the actual value of this angle. This might be obtained by Milch's method. On the basis of a clinical examination of 100 patients *Salmore* (6) found that the pelvi-femoral angle in adults was normally 50–52° and in children slightly higher (58°). These values are in agreement with those of Milch and the present authors. In the 10 cases of osteoarthritis examined, the pelvi-femoral angle in extension ranged from 60° to 90°, from which a flexion contracture of 10–40° was calculated. The difficulty of determining Nélaton's line accurately introduces a factor of uncertainty into the method.

Thomas' method for determining any flexion contracture has the following disadvantages: (i) A flexion contracture can sometimes be found in normal hips (Fig. 1 c). (ii) When the flexion mobility in the hip-joint not being examined is restricted the pelvis will begin to rotate early and then any contracture may be exaggerated, or a contracture may be recorded where none exists. (iii) In the case of a large abdomen or great flexion mobility of the hip-joint not examined an existing flexion contracture may remain undetected. (iv) Differences in the range of mobility of the pelvis in relation to the table (rigid or extreme-

ly mobile back) may result in too small or too large values for any flexion contracture.

It might be possible to obtain an impression of any flexion contracture from measurements on radiographs by comparing the actual extension with a normal value. In 10 normal subjects the angle between the femur and sacrum varied between 55 and 75° when the hip was fully extended. In some cases of osteoarthritis is was considerably greater—about 95–105°.

Until more information on normal variations is available this method can probably indicate only major deviations from the normal.

It is sometimes stated that the hip-joint in the erect position is fully extended and that it is the ileofemoral ligament that provides the stabilization of the joint. In the cases in which radiographic measurements were made in the erect position it was found that there was a flexion of the hip-joint, and thus that the stabilization was provided by muscles.

SUMMARY

A study has been performed of the range of mobility of the hip-joint. This was determined by the ordinary method of Thomas and the method of Milch and by making measurements on the radiographs. The study was performed on 95 normal subjects and 10 cases of osteoarthritis. It was found that Thomas' method gave too high and Milch's method much too low values. A new method for examining the range of mobility of the hip-joint was evolved on the basis of the radiographic analysis of the mobility of the joint and the pelvis during various manipulations. The values obtained by this method were in close agreement with the findings of the radiographic examination; the method showed that the sagittal range of mobility varies between 107 and 178° in the normal subject, and that it decreases with age.

RESUME

Il a été procédé à une étude sur l'étendue de la mobilité de l'articulation de la hanche. Celle-ci a été déterminée par les méthodes ordinaires de Thomas et la méthode de Milch et en effectuant des mensurations sur les radiographies. L'étude a porté sur 95 sujets normaux et 10 cas d'ostéoarthrite. Il a été découvert que la méthode de Thomas fournissait des données trop élevées et celle de Milch des données trop basses. Une nouvelle méthode pour examiner l'étendue de la mobilité de l'articula-

tion de la hanche a été développée sur la base de l'analyse radiographique de la mobilité de la hanche et du bassin durant des manipulations variées. Les valeurs obtenues par cette méthode concordaient étroitement avec les trouvailles de l'examen radiographique: la méthode montre que l'étendue sagittale de mobilité varie entre 107° et 178° chez le sujet normal et qu'elle diminue avec l'âge.

ZUSAMMENFASSUNG

Eine Untersuchung des Bewegungsausmasses des Hüftgelenkes wurde ausgeführt. Diese wurde mittels der gangbaren Methode von Thomas, der Methode von Milch und mittels Messungen an den Röntgenbildern bestimmt. Die Untersuchung wurde an 95 normalen Personen und in 10 Fällen von Osteoarthritis vorgenommen. Man fandt, dass die Methode von Thomas zu hohe und die Methode von Milch zu niedrige Werte ergiebt. Eine neue Methode zur Untersuchung der Beweglichkeit des Hüftgelenkes auf Grund einer röntgenologischen Analyse der Beweglichkeit des Gelenkes und des Beckens während verschiedener Manipulationen wurde daher entwickelt. Die Werte welche mit dieser Methode erhalten wurden, stimmen mit den Befunden der Röntgenuntersuchung gut überein: Die Methode zeigte, dass der Bewegungsumfang in der Sagittalebene bei normalen Personen zwischen 107° und 178° variiert und dass er mit zunehmendem Alter abnimmt.

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