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STATOMETRIC STUDIES ON PATIENTS OPERATED UPON FOR SLIPPED DISC IN THE LUMBAR REGION

By

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INTRODUCTION

Measurement of "posture", *i.e.* the measurement of the spatial orientation of the body in the erect position has been attempted by many authors who have used different methods. However, the principles are approximately the same: Trying to gain an objective impression of the body orientation in the erect position by photography, X-rays, or measurement direct on the body surface, using the plumb line as a line of reference.

By means of a cheap apparatus and a simple method *Mølhave* (1958) has worked out a method for measuring the spatial orientation of the body in the erect position.

Without discussing the concept good and poor posture, I should like to point out that in 1867 *Duchenne* noted the marked individual variations. He writes (*Kaplan's* translation 1949): "Thus, for instance, the Spanish women and especially the Andalusians, are known to possess beautiful spinal curves". And later "Women who have a very straight vertebral column or otherwise slightly flexed, have, generally speaking, a straight body with angular contours; the lines of their neck and shoulders are not graceful... the origin could well be Anglo-Saxon".

The object of the present study was to ascertain changes in the spatial orientation of the lumbar column and pelvis during the first 2 or 3 months after operation for slipped lumbar disc.

STATOMETRIC STUDY

It is a common finding that patients with slipped lumbar disc have, preoperatively as well as postoperatively, a diminished or obliterated lumbar lordosis, at times even a slight lumbar kyphosis.

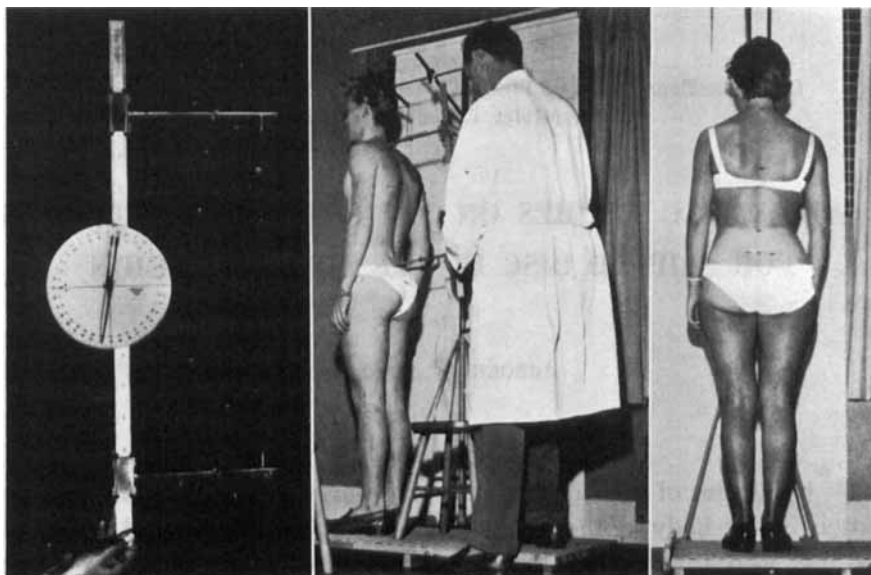
*Fig. 1.**Fig. 3.**Fig. 2.*

Fig. 1. Statometer.

Fig. 2. Dorsal Landmark.

Fig. 3. Landmarks on the lower limbs. The inclination between the vertebral prominens and interspinalion is demonstrated.

In an attempt at confirming objectively the above-mentioned clinical finding, patients who had undergone operation for slipped lumbar disc were subjected to measurement of the spatial orientation of the spine, pelvis, and lower limbs in relation to the plumb line, the so-called statometri of *Mølhave*. Three measurements were performed in each case, the first 3–4 weeks after the operation, the second after the completion of the postoperative rehabilitation period, and the third at follow-up about two years after the operation.

Statometri by the method of *Mølhave* is carried out as follows:

The examination is performed by specially trained physiotherapists using an apparatus called a statometer.

Fig. 1 illustrates a statometer, the recording disc and its pointer suspended in a ball bearing.

In order to be able to reproduce the same standing position accurately during the entire measuring procedure, the position has to be recorded. This is done by a direction finder, the two vertical direction rods being

placed in the same frontal plane as the tragus, and the position is read on the horizontal scale (= indicator point) (cf. Fig. 3, top).

The subject is wearing his usual shoes with flat heels.

The following landmarks are recorded:

(1) Tip of the lateral malleolus, (2) lateral femoral epicondyle, (3) middle of upper edge of greater trochanter, (4) posterior superior iliac spines and a point midway between these two called interspinalion, (5) deepest point of lumbar lordosis, (6) summit of thoracic kyphosis, (7) the vertebra prominens, (8) anterior edge of mastoid process.

Fig. 2 sets out the marking of the dorsal landmarks. Fig. 3 that of the landmarks on the lower limbs.

While the patient is in the "intention position", *i.e.* the standing position assumed before he starts walking (*Mølhave*) the physiotherapist measures, by means of the statometer, the inclination in relation to the plumb line, of:

(1) The lower limb: (a) from the tip of the lateral malleolus to the greater trochanter, (b) from the tip of the lateral malleolus to the lateral femoral epicondyle, (c) from the lateral femoral epicondyle to the greater trochanter.

(2) The pelvic inclination: From the pubic tubercle to the posterior

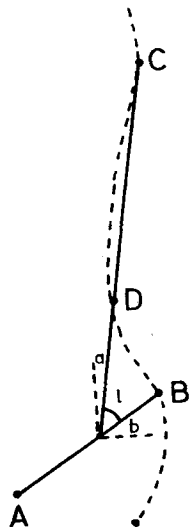


Fig. 4.

A: tuberculum pubicum. B: spina iliaca post. sup.
CD: lumbo-dorsal line.

iliac spine. However, this is measured in relation to the horizontal plane.

(3) Trunk: From the greater trochanter to the mastoid process.

(4) Spine: From the interspinalion to the vertebra prominens (cf. Fig. 3).

(5) Thoracic kyphosis: (a) From the indicator point to the summit of the thoracic kyphosis = the dorso-cervical line. (b) From the latter point to the deepest point of the lumbar lordosis = the lumbo-dorsal line.

(6) Lumbar lordosis: (a) Lumbo-dorsal line, (b) from the deepest point of the lumbar lordosis to the cornu of the sacral bone = sacro-lumbar line.

However, it often proved very difficult to determine with certainty the situation of the cornu of the sacral bone, so the sacro-lumbar line was not recorded. Instead, we determined the angle between the lumbo-dorsal line and a plane through the pubic tubercle and posterior superior iliac spine (= pelvic inclination) as an indicator of the lumbar lordosis. Fig. 4 shows that the angle l between the plane of pelvic inclination and the lumbo-dorsal line may be expressed by the following equation

$$\angle l = 90^\circ - (b + a)$$

On the figure points A and B represent the pubic tubercle and the posterior superior iliac spine respectively. Line CD represents the lumbo-dorsal line, $\angle b$ = pelvic inclination, and $\angle c$ = the inclination of the lumbo-dorsal line.

The distal part of the lumbar column follows the movements of the pelvis. A reduction in the pelvic inclination increases the angle between this plane and the lumbo-dorsal line, *i.e.* the lumbar lordosis becomes less concave. If the pelvic inclination increases, the concavity of the lumbar lordosis will increase, provided that the inclination of the lumbo-dorsal line is not reduced.

NORMAL VALUES

Mølhave's normal values, based on the statometric study of 106 men and 104 women, are as follows:

♂ lower leg: $5^\circ \pm 2^\circ$, thigh: $5^\circ \pm 2^\circ$.

Lower limb: $5^\circ \pm 1^\circ$. Pelvis $37^\circ \pm 4^\circ$.

Inclination of trunk: $0^\circ \pm 2^\circ$. Inclination of spine: $2^\circ \pm 2^\circ$. Dorso-

cervical line: $16^{\circ} \pm 2^{\circ}$. Lumbo-dorsal line: $-10^{\circ} \pm 3^{\circ}$. Lumbo-sacral line $8^{\circ} \pm 4^{\circ}$.

♀: Lower leg: $5^{\circ} \pm 2^{\circ}$, thigh: $6^{\circ} \pm 2^{\circ}$.

Lower limb: $6^{\circ} \pm 1^{\circ}$. Pelvis (pelvic inclination): $35^{\circ} \pm 4^{\circ}$. Inclination of trunk: $-2^{\circ} \pm 2^{\circ}$, inclination of spine: $2^{\circ} \pm 2^{\circ}$. Dorso-cervical line: $15^{\circ} \pm 2^{\circ}$, Lumbo-dorsal line $-10^{\circ} \pm 3^{\circ}$. Sacro-lumbar line $8^{\circ} \pm 4^{\circ}$.

The angle between the lumbo-dorsal line and the pelvic inclination averages $44^{\circ} \pm 5^{\circ}$ in both sexes.

All the above-mentioned measurements were performed, but in the present paper we shall be concerned merely with the results representing the pelvic inclination and the lumbar lordosis as well as the inclination of the lower limbs (*i.e.* lateral malleolus to greater trochanter) and of the spine as a whole (interspinalion to the vertebra prominens).

FIRST STATOMETRIC STUDY 3-4 WEEKS AFTER THE OPERATION

As already mentioned, the present study was designed to ascertain whether patients who have undergone operation for slipped lumbar disc exhibit deviations from normal in respect to the spatial orientation of the lumbar column and pelvis and whether these factors alter in the course of the postoperative period of rehabilitation.

The following requirements had to be fulfilled in order to perform statometry:

- (1) The patient had to be able to support equally on both legs, *i.e.* not have pain in the lower limbs which prevented a normal standing position.
- (2) There must not be major degrees of scoliosis of the thoracolumbar spine.
- (3) There must not be low-back pain causing fixation of the lumbar column.

Originally, the series comprised 125 patients who had undergone operation for slipped lumbar disc, but only 85 were estimated to fulfill the above-mentioned criteria.

The patients did not differ in age distribution or operative findings from other large operated series (*Busch et al.* 1949, *Shinners & Hamby* 1949, *Gottschalck & Højgård* 1961).

Table 1 presents the results of the investigation 3-4 weeks after the operation.

1st examination 3-4 weeks after the operation.
Pelvic inclination

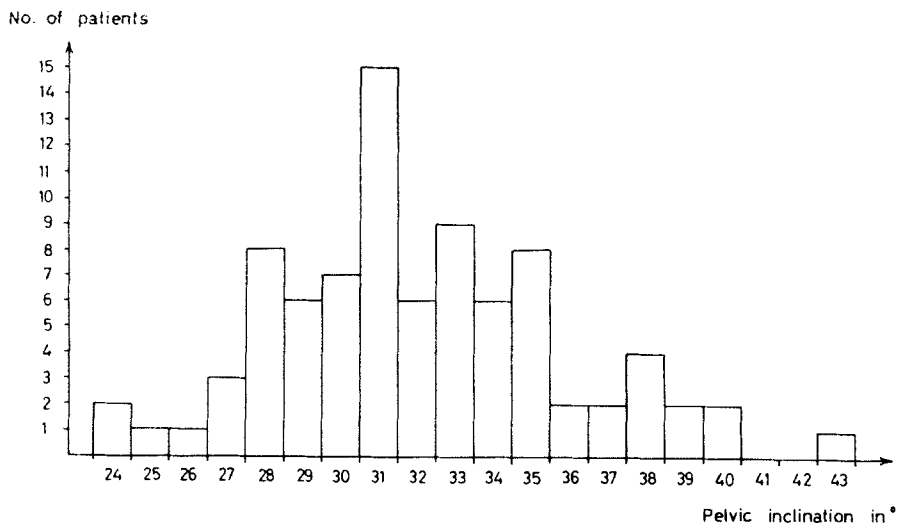


Fig. 5.

No. of patients

1st examination 3-4 weeks after the operation
Lumbar lordosis

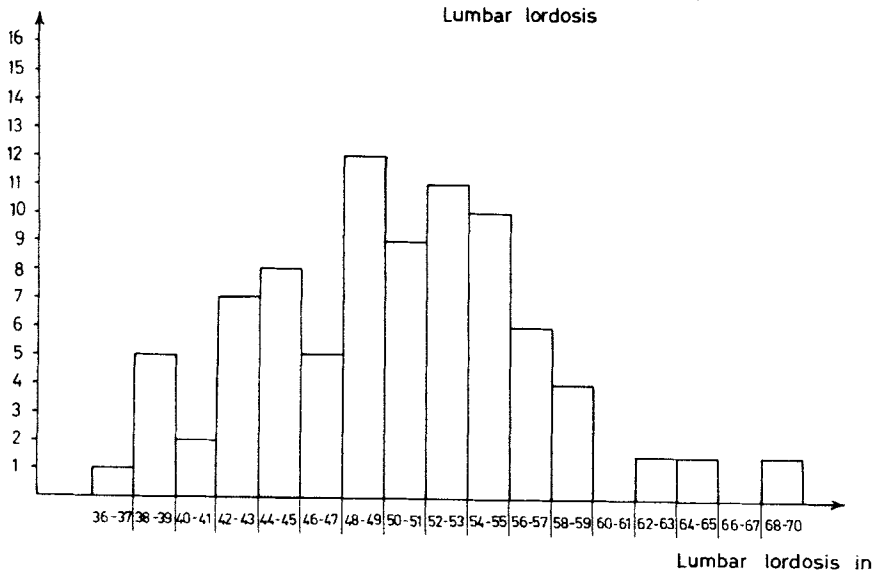


Fig. 6.

TABLE 1
Statometric Examination 3-4 Weeks after the Operation. 85 Patients.

		Normal values	Significance
Lumbar lordosis	$50.6^{\circ} \pm 6.3$	$44^{\circ} \pm 5$	0.001 >
Pelvic inclination	$32.1^{\circ} \pm 3.7$	$36^{\circ} \pm 4$	0.001 >

The pelvic inclination as well as the degree of lumbar lordosis differed significantly from normal values.

Fig. 5 gives the distribution of the pelvic inclinations. It shows that only a few patients had a pelvic inclination between 35° and 37° , the majority being in the range 28° – 33° .

Fig. 6 presents the distribution of the lumbar lordoses. Clearly, about half the patients had a lumbar lordosis of between 48° and 56° , while the normal value is 44° .

Therefore, it must be concluded that many patients who have undergone operation for slipped lumbar disc have a low pelvic inclination and a flattened lumbar lordosis. As a whole, the group differs significantly from a normal group, both in respect to pelvic inclination and degree of lumbar lordosis.

The inclination of the lower limbs, for the group as a whole, was $4.1^{\circ} \pm 2^{\circ}$ (normal value $5^{\circ} \pm 1^{\circ}$) and that of the spine as a whole $3.0^{\circ} \pm 2.6^{\circ}$ (normal value $2^{\circ} \pm 2^{\circ}$). These values differ significantly from the normal values ($0.01 < p < 0.001$). Thus, there is a tendency to carry the trunk forward and the lower limbs backward.

SECOND STATOMETRIC STUDY AT COMPLETION OF REHABILITATION PERIOD

During the first 8–10 weeks after the operation the patients were treated by (1) resistance exercises for spinal muscles, gluteal muscles, and the muscles of the lower limbs, (2) limbering-up exercises for the lumbar column, (3) massage and heat treatment.

After this treatment was completed, another statometric study was performed.

The results of this study were then to be compared with those of the statometry done 3–4 weeks after the operation.

Which criteria have to be fulfilled in order to compare two statometric studies?

The primary requirement must be that on repeated investigations of the same patient there are not major variations in the results owing to inaccuracy of measurement.

Mølhave demonstrated that on repeating the measurement the difference is usually not greater than $= 1^\circ$, in rare cases 2° .

In the second place, it must be demanded that for assessing alterations in the pelvic inclination or of the lumbar lordosis, the standing position should not as a whole differ essentially from one measurement to the other. In other words, the inclination of the lower limbs (measured from the tip of the lateral malleolus to the middle of the upper edge of the greater trochanter) and the inclination of the spine as a whole (measured from the interspination to the vertebra prominens) must not differ essentially from one measurement to the other.

Therefore, the following criteria for the comparability of two statometric studies were set up:

The inclination of the lower limbs must not vary by more than $\pm 2^\circ$ from one measurement to the other.

The inclination of the spine as a whole must not vary by more than $\pm 2^\circ$ from one measurement to another.

When these criteria are observed, an increase in pelvic inclination, for instance, cannot be due to forward bending of the entire spine and pelvis, but it must be an isolated alteration in the orientation of the pelvis. Similarly, an increase in lumbar lordosis cannot be explained by backward extension of the trunk.

Moreover, it has been demonstrated by *Floyd & Silver* (1955) that the minor oscillations which constantly occur in the standing position take place almost exclusively in the ankle joints. This means that the curvatures of the spine are practically independent of the slight alterations in the inclination of the lower limbs.

Provided that the above-mentioned criteria are observed, the statometry of 67 patients performed 3–4 weeks after the operation is comparable with that performed at the end of the rehabilitation period.

From Table 2 it may be seen that there had been a significant increase in the pelvic inclination and a significant accentuation of the lumbar lordosis. The accentuation of the lumbar lordosis (*i.e.* the diminution of the angle between the lumbo-dorsal line and the pelvic inclination) is twice as marked as the alteration of the pelvic inclination. This shows that the alteration is not localized merely to the distal part of the lumbar column and pelvis, but also to the proximal part. These values differ significantly from the normal values ($p < 0.001$).

TABLE 2
*Alterations in Pelvic Inclination and Lumbar Lordosis during
 the Rehabilitation Period. 67 Patients.*

	1st statometry 3-4 weeks after the operation	Statometry at termination of re- habilitation period	Significance
Pelvic inclination ...	32.28 ± 3.8	34.73 ± 2.9	< 0.001
Lumbar lordosis	50.23 ± 5.6	46.55 ± 4.5	< 0.001

TABLE 3

	Pelvic inclination at 1st measurement 3-4 weeks after the operation	Lumbar lordosis at 1st measurement 3-4 weeks after the operation
Patients showing changes in pelvic inclination of 2° or over during the postoperative period. 38 patients ...	$30.42^\circ \pm 2.52$	$53.45^\circ \pm 4.2$
Patients showing no changes in pel- vic inclination $\pm 1^\circ$ during the post- operative period. 29 patients	$34.76^\circ \pm 3.83$	$46.26^\circ \pm 5.4$
Significance	$P < 0.001$	$P < 0.001$

Final examination during the postoperative period.

Pelvic inclination

No. of patients

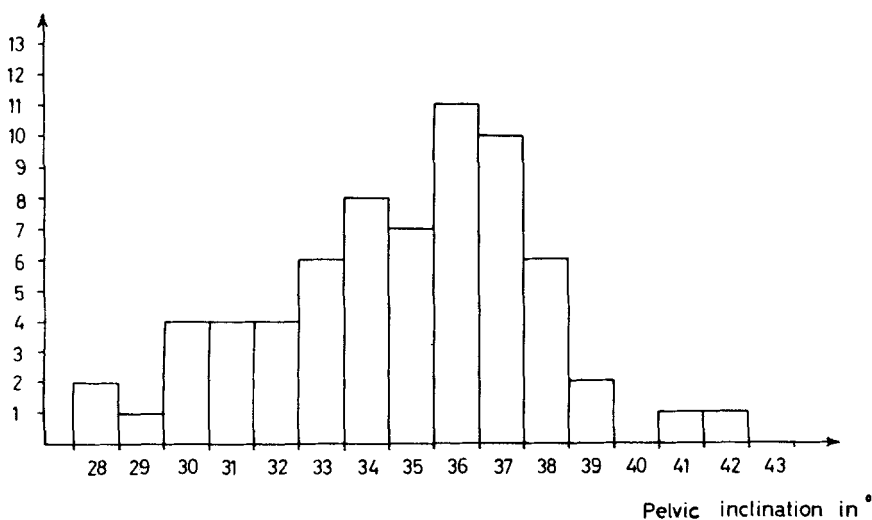


Fig. 7.

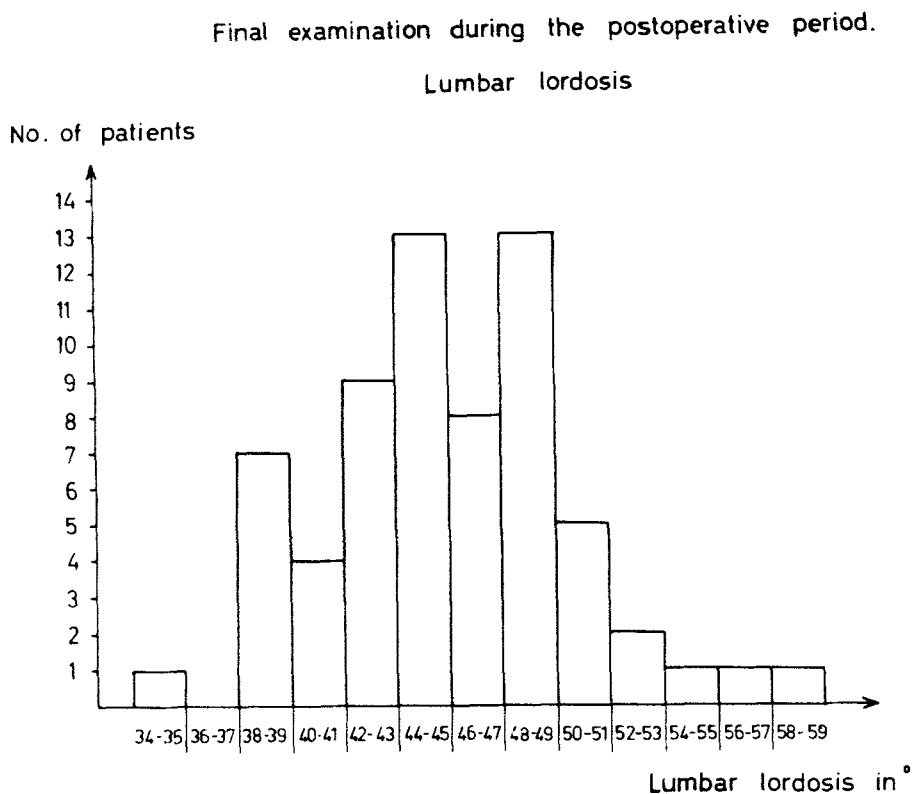


Fig. 8.

Table 3 demonstrates that alterations in pelvic inclination of 2° or over occur particularly in patients who showed, at the first investigation, a slight pelvic inclination and a flattened lumbar lordosis. In patients who did not exhibit an alteration of the pelvic inclination of more than 1° the values had been close to normal on occasion of the first statometry.

Fig. 7 shows the distribution of the values found for pelvic inclination. A comparison with Fig. 5 reveals that a shift has taken place towards higher values, the greater part of the values being about 35° - 37° , *i.e.* close to the normal values found by *Molhave*.

Fig. 8 gives the distribution of the angles found between the lumbodorsal line and the pelvic inclination, *i.e.* the lumbar lordosis. Comparison with Fig. 6 shows, in this respect too, a clear shift towards lower values.

Summing up, it may be concluded that many patients who have

undergone operation for slipped lumbar disc show a dysstatic condition of the lumbar column and the pelvis, manifesting itself in a reduced pelvic inclination and a flattened lumbar lordosis.

After the operated patients have been through a period of rehabilitation, the pelvic inclination and the degree of the lumbar lordosis often approach normal. However, the group as a whole, differs significantly from *Mølhave's* normal values ($p < 0.001$).

The present study, however, does not permit the final conclusion that the alterations represent a direct consequence of the exercise therapy, as we have no control group. But it seems reasonable, when other factors indicate exercise therapy, to give the patients a treatment which supports a possible spontaneous tendency to normalizing the static conditions in the lumbar spine and pelvis.

THIRD STATOMETRIC STUDY ABOUT 2 YEARS AFTER THE OPERATION

A repeated statometric study was carried out at follow-up an average of 25.5 months after the operation.

A source of error in the statometric study performed at the completion of the rehabilitation period might be that in the course of the daily exercise therapy the patients had got a feeling that they were expected to be able to produce a lumbar lordosis. Consciously or unconsciously, the might, therefore, have assumed an artificially increased pelvic inclination and an increased lumbar lordosis at the time of the measurement.

Such a motive would probably not play any role at follow-up so many months after the operation. The patients have then presumably forgotten both which exercises they did and the motivation for performing them.

An unchanged statometric result at follow-up would mean that the alterations occurring in the first 2 or 3 months after the operation were permanent and not a result of a temporarily acquired posture.

A comparison of the values found at follow-up with those observed at the completion of the rehabilitation period could be made in only 56 of the 67 patients, partly because some of them failed to attend follow-up and partly because of the above-mentioned criteria.

Table 4 shows no significant difference between the two studies, neither in respect to the degree of pelvic inclination nor of lumbar lordosis.

TABLE 4
Statometric Examination at Follow-Up about 25 Months after the Operation.

	Statometry at the termination of the rehabilitation period	Statometry at follow-up	Significance
Pelvic inclination	34.73 ± 2.9	34.27 ± 3.2	> 0.1
Lumbar lordosis	46.55 ± 4.5	47.47 ± 4.9	> 0.1

Then, it must be concluded that the increase in pelvic inclination and the diminution of the angle between the lumbo-dorsal line and the plane of inclination observed in the postoperative rehabilitation period are not temporarily acquired, but permanent alterations.

SUMMARY

The method of *Molhave* for measuring the spatial orientation of the body is described. This method is called statometry. Only the results in respect to pelvic inclination, lumbar lordosis, inclination of the lower limbs and of the spine as a whole were used in the present study.

Out of a series of 125 patients who had undergone operation for slipped lumbar disc 85 were subjected to statometry 3–4 weeks after the operation. At the completion of the postoperative rehabilitation period the patients were re-examined, but the results were comparable in only 67. About 2 years after the operation a follow-up statometry was performed.

At the time of the first statometry the group as a whole showed significant differences from *Molhave's* normal values in respect to the degree of pelvic inclination and of lumbar lordosis, the pelvic inclination being diminished and the lumbar lordosis flattened.

After the rehabilitation period these factors had altered. The pelvic inclination had increased and the lumbar lordosis had been re-established but without returning quite down to *Molhave's* normal values.

At follow-up about 2 years after the operation the group as a whole showed an unchanged pelvic inclination and lumbar lordosis as compared with the results at the end of the rehabilitation period.

Therefore, it seems rational to subject patients of this category to postoperative exercise therapy aiming at increasing the pelvic inclination and re-establishing the lumbar lordosis.

RESUME

La méthode de *Möhlhave* pour mesurer l'orientation spatiale du corps est décrite. Cette méthode est appelée statométrie. Seuls les résultats concernant l'inclinaison pelvienne, la lordose lombaire, l'inclinaison des membres inférieurs et de l'ensemble de la colonne vertébrale ont été utilisés dans la présente étude.

Sur une série de 125 malades ayant été opérés pour hernie discale lombaire, 85 ont subi un examen de statométrie 3-4 semaines après l'opération. A la fin de la période de réadaptation post-opératoire, les malades ont été réexaminés, mais les résultats n'ont été comparables que dans 67 cas seulement. Environ 2 ans après l'opération, une statométrie de contrôle a été pratiquée.

A l'époque de la première statométrie, on a constaté dans l'ensemble du groupe une différence marquée par rapport aux données normales de *Möhlhave* concernant le degré d'inclinaison pelvienne et de lordose lombaire, l'inclinaison pelvienne étant diminuée et la lordose lombaire aplatie.

Après la période de réadaptation, ces facteurs s'étaient altérés. L'inclinaison pelvienne avait augmenté et la lordose lombaire avait été rétablie, mais sans revenir entièrement aux données normales de *Möhlhave*.

Au réexamen, environ 2 ans après l'opération, le groupe avait dans l'ensemble une inclinaison pelvienne et une lordose lombaire inchangées par comparaison avec les résultats relevés à la fin de la période de réadaptation.

Il paraît rationnel, dans ces conditions, de soumettre les malades de cette catégorie à une thérapie d'exercices post-opératoires susceptibles d'accroître l'inclinaison pelvienne et le rétablissement de la lordose lombaire.

ZUSAMMENFASSUNG

Die Methode von *Möhlhave* zur Messung der räumlichen Orientierung des Körpers wird beschrieben. Diese Methode wird Statometrie genannt. Die Ergebnisse hinsichtlich Beckenneigung, Lendenlordose, Neigung der unteren Gliedmassen und der Wirbelsäule als Ganzes wurden allein in dieser Untersuchung verwendet.

Von einer Reihe von 125 Patienten, die einer Operation wegen vorgefallener Lendenzwischenwirbelschreibe unterworfen worden waren, wurden 85 drei bis vier Wochen nach der Operation mittels Stato-

metrie untersucht. Nach Vollendung der postoperativen Wiederherstellungsperiode wurden die Patienten wiederuntersucht. Das Ergebnis war jedoch nur bei 67 Patienten vergleichbar. Ungefähr zwei Jahre nach der Operation wurde eine Nachuntersuchung mittels Statometrie ausgeführt.

Bei der ersten Statometrie zeigte die Gruppe insgesamt bezeichnete Abweichungen von *Möhlhaves* normalen Werten hinsichtlich des Grades der Beckenneigung und der Lendenlordose, indem die Beckenneigung verringert und die Lendenlordose abgeflacht war.

Nach der Wiederherstellungsperiode hatten sich diese Faktoren verändert. Die Beckenneigung hatte zugenommen und die Lendenlordose war wiederhergestellt, jedoch ohne die normalen Werte von *Möhlhave* ganz zu erreichen.

Bei der Nachuntersuchung ungefähr 2 Jahre nach der Operation zeigte die Gruppe im Ganzen eine unveränderte Beckenneigung und Lendenlordose im Vergleich mit dem Ergebnis am Ende der Wiederherstellungsperiode.

Es erscheint daher logisch derartige Patienten einer postoperativen Übungsbehandlung, die auf die Zunahme der Beckenneigung und Wiederherstellung der Lendenlordose abzielt, zu unterwerfen.

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