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POSTOPERATIVE MANAGEMENT IN LUMBAR DISC PROTRUSIONS

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INDICATIONS, METHOD and RESULTS

INTRODUCTION

Since *Mixter & Barr,* in 1934, published their epochmaking study on the lumbar disc syndrome, the indications for its surgical treatment have not altered in any essential way.

In the course of time a large number of papers on this richly facetted subject have seen the light of day. In Denmark *Malmros* (1942) and *Busch et al.* (1949) have given a detailed description of the symptoms and signs as well as the treatment of slipped lumbar disc. But in respect to data regarding the postoperative management, defined as the treatment of the patients during the first 8—10 weeks after the operation, the literature is extremely meagre. And in the event of any reference to the problem, opinions are highly divided.

It is characteristic, and perhaps realistic, that *Busch et al.* make only brief mention of postoperative treatment — in the form of massage and application of heat — and only in relation to patients having pain during the postoperative period.

The lacking interest in postoperative care might perhaps mean that no problem exists. Or in other words: When the lumbar disc protrusion has been removed, the prognosis is settled, irrespective of postoperative treatment, if any. Therefore, this treatment is of no significance and consequently also of no interest. This is perhaps right, but if the postoperative treatment is mentioned at all, the methods are very different. In *Armstrong's* (1951) opinion, for instance, any form of exercises to increase the suppleness of the lumbar spine during the first 6 postoperative weeks is harmful, since an astymptomatic, fibrous ankylosis at the site of the involved disc must be the object of the treatment. *Kristiansen* (1961) employs immobilization in a corset as early as 8 days after the operation. Thus, the above authors believe in immobilization.

Poppen (1945), *Spurling & Grantham* (1949), *Woolsey & Tsang* (1952) and *Hirsch* (1959) discharge the patients 11, 14, 7, and 5 days respectively after the operation without further treatment.

Munro (1956), on the other hand, feels that postoperative treatment is equally important as the operation, if the patients are to return soon to their work. *O'Connell* (1951) considers exercises to increase the suppleness of the spine important during the postoperative period. *Anderson et al.* (1961), *Keijser* (1961), *Aldes* (1952) and *Sparup* (1960) state that there is a requirement for training the strenght of the back extensors and for increasing the suppleness of the lumbar column.

However, it is a common feature of all the above-mentioned divergent views that they generalize. *Cadwell & Sheppard* (1948) hold a more individualistic view, maintaining that in particular the patients who are classified as »satisfactory« at follow-up are in need of treatment. Factors such as obesity, poor posture, a stiff back, and a poor general condition are mentioned as indications for after-treatment. *Andersen et al.* also advocate individualized treatment.

Obviously, therefore, there is a marked conflict of opinion as to whether there is a requirement at all for postoperative rehabilitation of patients who have undergone operation for herniation of lumbar intervertebral disc. And if after-treatment is found to be indicated, the methods vary within wide limits.

The object of the present study was to:

(1) investigate whether patients operated upon for lumbar disc lesions are in need of postoperative rehabilitation,

(2) to investigate the results of physical rehabilitation.

In the effort to elucidate these aspects, a group of patients was investigated both 3—4 weeks after the operation and at the end of the rehabilitation period about 3 months after the operation.

MATERIAL

The group originally comprised 128 patients, but 3 did not complete the postoperative treatment and were excluded, leaving a total of 125. These patients had primarily been admitted to the Department of Physical Medicine and then transferred to the Department of Neurosurgery. About one week after the operation the patients were transferred back to the Department of Physical Medicine.

Table I gives the age distribution and sex ratio.

Towards the end of the postoperative rehabilitation period the patients were divided into the following groups:

Group I: Symptom free.

Group II: Occasionally moderate low-back pain or pain in the legs similar to the preoperative pain, but of low intensity and with long free intervals. Not inhibited in the daily work during the free intervals.

Group III: Constant complaints. This group is inhomogeneous, including both patients who were severely disabled and patients whose symptoms were of moderate intensity. The patients were inhibited in their daily work.

Table 1. *Age distribution.*

Group	I	II	III	Total
15—20	1	0	0	1
21—30	11	2	2	15
31—40	46	10	6	62
41—50	15	7	10	32
51—60	4	4	5	13
61—70	0	1	1	2
Total	77	24	24	125
Females / Males	34 / 43	13 / 11	15 / 9	62 / 63

From Table I it may be seen that the majority of the patients were between 30 and 50 years of age. This is in keeping with the age distribution observed in far larger series *(Busch et al.* 1949, *Aitken* 1952, *Gottschalck & Højgård* 1961).

The sex ratio is approx. 1 : 1. Most other authors have reported a preponderance of male patients: *Mixter* (1937) 77 %, males, *Love* (1939) 75 %, *Malmros* (1942) 63 %, *Knutsson* (1961) 60 %, and *Busch et al.* (1949) 54 %. Thus, the last-mentioned series, which comprised 1000 patients, also showed and approximately equal sex ratio.

There was no selection of the patients, as they were included in the series in the order that they were admitted to the department.

Nearly all the herniations were at the 4th and 5th lumbar disc (97.5 %), just as in other and larger series. 2.5 % were at the 3rd lumbar disc.

The operations consisted in 114 hemilaminectomies, 6 laminectomies, and 5 transligamentous operations.

Preoperative X-ray examination of the lumbar column revealed (Table II) that 44 % had normal discs and vertebral bodies, 49 % had

only minor degenerative changes in or at the lumbar disc, and 7 % massive degenerative changes. These values are of the same order as reported by *Barr* (1939), *Love* (1939), *Busch et al.* (1949), and Schalimtzek (1958).

Table 2. *Preoperative X-ray examination of the lumbar spine.*

	Number of patients			
Group	I	II	III	Total
No abnormality	39	9	6	54 (44 %)
Mild degeneration of the lumbar intervertebral discs	32	13	15	60 (49 %)
Severe degeneration of the lumbar intervertebral discs	3	2	3	8 (7 %)

No X-rays were available in 3 cases.

From the above it must be concluded that this group of patients does not differ essentially from any non-selected surgically treated group.

THERAPEUTIC AND DIAGNOSTIC, METHODS.

A. Therapeutic methods.

(1) *Duration of bed rest:* The patients were allowed out of bed 10 days after the operation. Most previous authors have reported a considerably shorter postoperative bed rest, but a few longer. *Clark* (1957) ambulates his patients as early as the day after the operation, *Woolsey et al.* 2 or 3 days after the operation, *Poppen* (1945) on the 7th day, *O'Connel* on the 8th day, *Spurling* (1949) and *Keijser* 14 days after the operation.

In my opinion it would be reasonable to individualize the length of the postoperative bed rest, but this had not been done in the present series. Some patients can easily get op on the 3rd or 4th day, while others have little inclination to get up 10 days after the operation.

On the 10th postoperative day the patients were out of bed for 15 minutes, on the 11th day for 30 minutes, on the 12th day for 60 minutes, and so on.

(2) *Exercises during postoperative bed rest:* Free, active exercises and resistance exercises of both lower limbs. In some cases electrical stimulation of severely paretic muscles.

On approx. the 8th day the patients were transferred back to the Department of Physical Medicine.

(3) *Exercises after the patients get out of bed:* About 2 weeks after the operation a more active treatment was instituted. After heating the lumbar and gluteal regions by hot dressings, the patients had, depending on the clinical findings:

(a) exercises to increase the suppleness of the lumbar and thoracic spine, but without forward flexion during the first month.

(b) exercises to lengthen the hamstring muscles.

(c) resistance exercises for the paretic muscles in the gluteal region and on the legs.

(d) exercises for the trunk extensors, carried out in the prone position with the arms along the side. The upper part of the trunk was elevated, while the legs were held fixed by the physiotherapist. At the outset training without extra loading, later with sand bags across the upper part of the thoracic region. The duration of contraction was 5—10 sec. The loading was increasing, in the case of males usually up to 15 kg, exceptionally higher (up to about 25 kg), and in females usually up to about 10—12 kg.

(e) lordosing exercises for the lumbar spine.

(f) massage of tender muscles in the lumbar region, gluteal region, and lower limbs.

This treatment was given daily and continued after discharge on an out-patient basis. Patients from other parts of the country were kept for quite a long time in the department, and all were encouraged to continue the exercises on their own after discharge.

B. Test Methods:

(1) *Conventional clinical evaluation:* About 3 or 4 weeks after the operation and at the end of the rehabilitation period the patients were subjected to a thorough clinical evaluation. The former evaluation was done to decide the need for rehabilitation, qualitative as well as quantitative, the latter to assess the result of the rehabilitation.

A number of previous publications have shown that the great majority of patients have been discharged and the treatment concluded before the 20th postoperative day.

Woolsey et al. (1952) discharge their patients 7 days after the operation, *Poppen* (1945) has an average stay in hospital of 11 days, and *Spurling* (1948) of 14 days. *Busch et al.* (1949), however, had discharged only 70 % of the patients 20 days after the operation.

It seems reasonable, 3 or 4 weeks after the operation when neurosurgical supervision has been concluded, to estimate whether there has been or still is a requirement of rehabilitation and continued medical supervision.

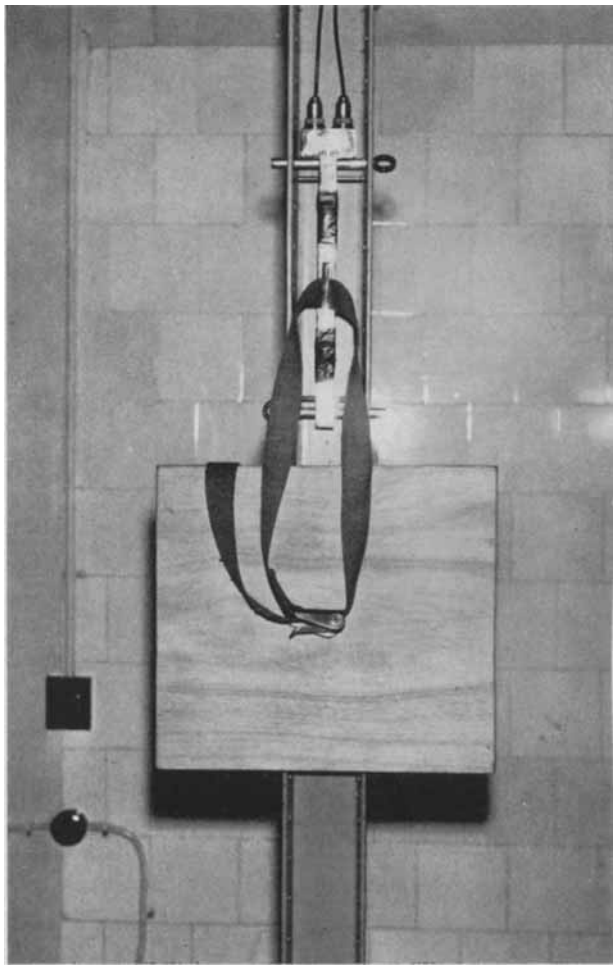

Fig. 1. Strain gauge dynamometer.

The investigation consisted in (a) recording symptoms, (b) neurological examination of the lower limbs, (c) assessment of the mobility of the spine (finger-floor distance and lateral flexion), (d) evaluation of muscle strength in the lower limbs, including the gluteal muscles, (e) Lasegue test, (f) palpation of back muscles and gluteal muscles.

(2) *Measurement of strength in trunk extensors:* 3 or 4 weeks after the operation and at the end of the rehabilitation period the following determinations were made: (a) Isometric strength of the trunk extensors (tr. ext.) by a strain gauge dynamometer (Fig. 1). The result was automatically recorded on a self-balancing recorder (Philips PR 2210

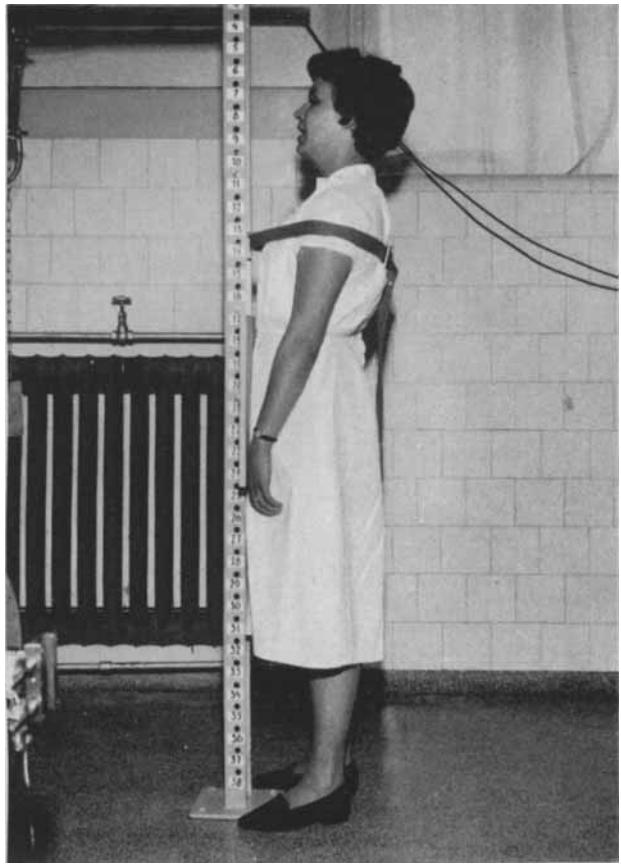

Fig. 2. Test for trunk extensors.

P/00). The technique of this test is illustrated in Fig. 2. It was carried out by the method recommended by *Asmussen et al.* (1961). In each measurement 5 contractions were performed. The maximum result was considered to represent the isometric strength of the tr. ext.

(b) The isometric strength of the tr. ext. was determined by measuring the isometric endurance of the tr. ext. when loaded with a weight equal to that of the upper part of the body.

Investigations by *Rohmert* (1960), *Monod* (1956), *Samson* (1953), and *Scherrer & Monod* (1960) have shown, that the isometric endurance of a muscle synergy depends upon the loading in the way that a hyperbolic curve results, when the relation between loading and isometric endurance is plotted in a coordinate system. If the loading is expressed in per cent of maximum strength, the isometric endurance on the same

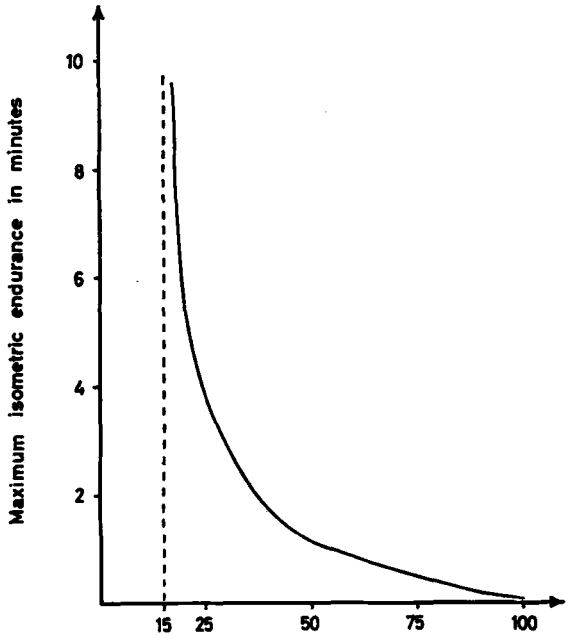

Fig. 3. Strength stated in per cent of maximum strength.

percental tension level will be independent of the absolute strength of the muscle synergy and independent of which muscle group is being investigated *(Rohmert).*

The relation between isometric endurance and loading, in per cent of maximum strength, will be seen in Fig. 3 (after *Rohmert).* At the 15 % level the endurance is almost infinite. *Rohmert* has reported the following values:

Table 3.

Tension in % of max. tension	Lower limit for 90% of the measurements
75	≧ 0.35 MIN. = 21 SEC.
50	≧ 1.01 MIN. = 60 SEC.
25	≧ 3.4 MIN. = 204 SEC.

In a determination of the isometric endurance of the tr. ext., when loaded with a weight equal to that of the upper part of the body (defined as that part of the body which is cranial to a level through the upper points of the iliac crest), it will be slight, if the strength of the tr. ext. is slight in relation to the loading, i. e. the weight of the upper part of the body. Reversely, the endurance will be great if the

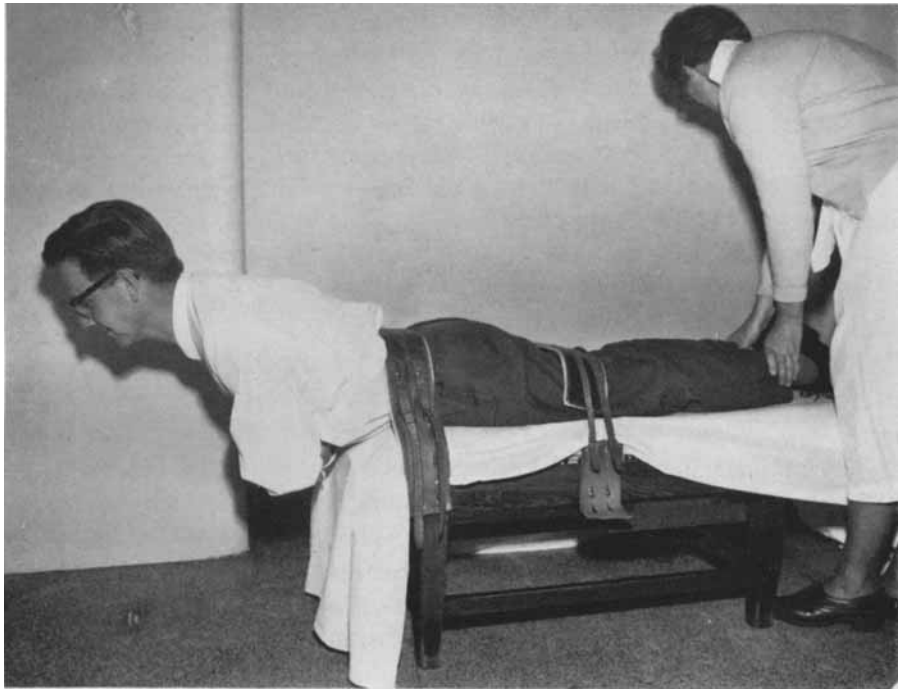

Fig. 4. Endurance test for trunk extensors.

strength is great in relation to the weight of the upper part of the body. The technique of this test is shown in Fig. 4.

The subject was placed prone upon a vaulting horse, the edge of the horse being on a level with the upper edge of the iliac crest. A leather girdle was strapped around the gluteal region and another around the thighs, while the investigator supported the lower legs. Thus fixed, the subject was asked to cross his arms over the distal part of the chest and to keep the upper part of the body horizontal for as long as possible.

This test was carried out on 168 healthy persons (physiotherapists and athletes) who had no signs of spinal disease. The results are given in Table 4.

It will be seen that 64 % had an isometric endurance of 240 sec. True, the test was discontinued at this time, but the 4-minute limit was in all these subjects practically the maximum obtainable. 78 % were above 3 minutes and 95 % above 2 minutes. In most normal persons, therefore, the trunk extensors are capable of lifting a maximum weight which is about 3 times the weight of the upper part of the body under these experimental conditions (cf. curve on Fig. 3).

The body weight of the subjects was within the range: normal weight ± 20 %, except in 4 (2 above and 2 below). Their height ranged from 150—195 cm, 56 % being between 165 and 175 and the others evenly distributed above and below.

Table 4. *Isometrisk endurance test for trunk extensors. 168 subjects (83 males + 85 females).*

Number of seconds	Number of subjects
0— 60	0
61—120	8
121—180	29
181—240	25
≧ 240	106

The majority of the subjects were between 18 and 30 years of age (80 %), i. e. at the age where muscle strength is at its height *(Hettinger & Müller* 1951 and 1958, *Ufland* 1933). The named authors, however, also found that the muscle strength decreased by only about 10 % from 25 to 50 years of age. Thus, the strength of the tr. ext., and thereby the isometric endurance of the present subjects, should not differ essentially from that in a group of a more even age distribution.

The results show a marked dispersion which was only to be expected.

In the first place, the strength of the tr. ext. is said to vary considerably in normals. *Asmussen & Heebøll-Nielsen* (1961) found a standard deviation of about 15 % in persons of the same age and height. Thus, normal persons of the same height and age will also show marked variations in isometric endurance.

Secondly, the weight of the upper part of the body in relation to the strength of the tr. ext. is of importance, as small percental alterations give rise to pronounced differences in time (cf. curve Fig. 3).

Thirdly, the subjects' determination to perform the test is of considerable importance.

Summing up, it may be concluded that an isometric endurance test of the tr. ext. with a loading corresponding to the weight of the upper

part of the body is applicable as a rough determination of the strength of the tr. ext. A lower limit of 2 min. is a minimum, which practically everyone ought to be able to attain (body weight = normal weight ± 20 %, age under 50).

A lower limit of 3 minutes is a reasonable goal to aspire to in training the tr. ext.

At an isometric-endurance of more than 3 minutes even small changes in the relation between the strength of the tr. ext. and the weight of the upper part of the body will result in marked changes in endurance. Moreover, the subject's determination to perform the test is a factor of great significance.

Despite these factors of uncertainty, there are often situations in which it is of great value to be able to obtain — without the use of expensive apparatus and with submaximal loading — if only a rough measure of the strength in the tr. ext. The test seems to be applicable for this purpose.

(3) *Statometry:* By a statometric test by the method of *Mølhave* (1958) the spatial orientation of the head, trunk, spine, pelvis, and lower limbs was determined in relation to the perpendicular.

This test was carried out 3 or 4 weeks after the operation and at the end of the rehabilitation period.

A detailed description of this study is in print *(Hansen* 1964).

RESULTS.

A. Evaluation 3—4 Weeks After the Operation.

The muscle test was performed, as stated previously, by the principles of *Kendall* (1949).

Table 5 gives the result. It shows that 45 patients (36.6 %) did not have pareses, while 68 (56 %) had mild pareses (strength degree 4), and 9 (7.4 %) had severe pareses (strength degree 0—3). A reduced strength was often found in the hip muscles, especially the hip extensors and abductors. These groups are also innervated predominantly by the 4th and 5th lumbar and the first sacral nerve. However, an evaluation of the strength in both muscle groups presupposes fixation

Table 5. *Manual assessment of muscle strength in lower limbs.*

	Number of patients									
	1st investigation					Final investigation				
Group	I	II	III	total	%	I	II	III	total	%
No pareses	29	9	7	45	36.6	60	18	8	86	70.5
Mild pareses degree 4	42	14	12	68	56	13	4	13	30	24.5
Severe pareses degree 0—3..	4	1	4	9	7.4	2	1	3	6	5.0
Pareses in the muscles of the pelvic girdle	26	11	11	48		6	3	6	15	

3 patients could not be assessed.

of the lumbar spine. Inability to fix the lumbar spine because of pain may constitute a source of error, but I tried to assess the role of this source in each individual case.

The result of Lasegue's test is set out in Fig. 5. Only groups I and II are included, as in these patients it was reasonable to assume that the compression to the nerve roots had been relieved. It is apparent that many patients were in definite need of lengthening of muscles on the posterior aspect of the thigh and/or mobilization of the lumbar nerve corresponding to the operated disc. The mobility of the spine in the sagittal plane was determined by measuring the distance between the finger tips and the floor in maximum forward flexion with extended knees.

The result is given in Table 6. It will be seen that a considerably restricted mobility was found in the thoracic and lumbar spine, even in patients, who were cured by the operation (groups I and II). The

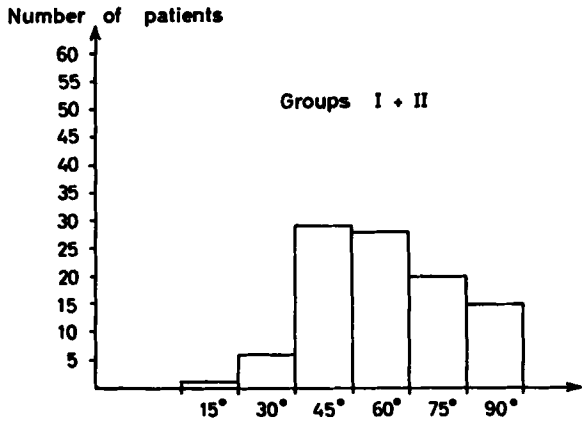

Fig. 5. Maximum elevation of lower limb with extended knee (Lasegué test) 3—4 weeks after the operation.

Table 6. *Finger-floor distance in cm.*

Group	I	II	III
About 3 weeks after the operation	33	36	36
Final investigation within the post-operative rehabilitation period....	12	16	25

same factors which were mentioned under the heading of Lasegue's test also play a part in this respect.

Palpation of the tr. ext., gluteal muscles, and muscles on the lower limbs revealed that about 80 % of the patients were in need of massage of tender muscles.

Table 7. *Isometric strength in trunk extensors 29 patients.*

	Per cent of normal strength
1st investigation 3—4 weeks after the operation	48.8
Final investigation within the rehabilitation period	85.1

The strength of the tr. ext., measured directly by means of the above-mentioned strain gauge dynamometer, was reduced to about 50 % of normal (Table 7). Since the apparatus was not available until the latter part of the experimental period, only 29 patients were evaluated in this way. Only patients in whom the test did not induce pain, which was the usual finding, were included in the calculation. Indirect determination of the strength of the tr. ext. by isometric endurance test also showed that many patients had considerable insufficiency of the tr. ext (Table 8).

Table 8. *Isometric endurance test for trunk extensors Groups I + II.*

Sec.	1st investigation 3—4 weeks after the operation	Final investigation within the postoperative period
0— 30	31	2
31— 60	24	5
61—120	31	26
121—180	7	26
181—240	0	11
> 240	1	9

At the 1st investigation 7 patients could not be assessed or refused to have the test.

At the final investigation 12 patients could not be assessed or refused to have the test.

Only patients of groups I and II are included in this table and only patients who could carry out the test without pain — which was the general rule.

The patient's weight was within the normal range ± 20 % except in 13 cases. Four were below this limit and 9 above. In 3 of the overweight patients the test could not be done because of the large abdomen. In the other 6 the times obtained in the 1st test were 140 sec., 80 sec., 10 sec., 12 sec., 12 sec., and 25 sec. In the 4 underweight patients the times were 140 se., 35 sec., 45 sec., and 40 sec. In other words, there were both strong and weak persons in both groups.

Only 8 patients were above the 2-minute level and only 1 above the 3-minute level.

As may be seen from the table the test was carried out 3 or 4 weeks after the operation, i. e. at a time long after the discharge from the department of neurosurgery. Although at this juncture an otherwise completely or almost symptom free patient will be rather reluctant to strain his back muscles for some time, and although the loading is far from maximal, the result of the isometric endurance test must be interpreted to the effect that many patients have reduced strength in the trunk extensors.

Table 9. *Statometric examinations 3—4 weeks after the operation. 85 patients.*

		Normal values	Significance
Lumbar lordosis ..	50°.6 ± 6.3	44° ± 5	0.001 >
Pelvic inclination..	32°.1 ± 3.7	36° ± 4	0.001 >

Only 85 patients were considered suited for the statometric study. The criteria were as follows: (1) No major scoliosis, (2) no fixation of the thoracic-lumbar spine by pain.

Table 9 shows that the mean values for the pelvic tilt and for the lumbar lordosis, defined as the angle between the lumbo-dorsal line and a plane through the pubic tubercle and the posterior-superior iliac spine (cf. *Hansen,* 1964) differ significantly from the normal values given by *Mølhave.*

A collected evaluation of the rehabilitation requirement 3—4 weeks after the operation among the patients who made up groups I and II gave the following result:

Table 10. *Need for rehabilitation in Groups I and II.*

	Group I	Group II
No definite need for rehabilitation	27	4
Slight, but definite need for rehabilitation	30	13
Considerable need for rehabilitation	20	7

Only 30 % had no definite requirement. This is taken to mean that although clinical examination showed e. g. a Lasegue of 60°, isometric tr. ext. strength of 80 % the normal, and isometric endurance of the tr. ext. of 120 sec., these patients were not believed to be in particular need of physical rehabilitation. Everyday work would no doubt soon normalize the condition. About 43 % had a slight, but definite, and 27 % a considerable need for treatment.

Group III, i. e. that in which the patients had constant complaints from the lumbar region or legs during the postoperative period consisted of 24 persons. The strength of the tr. ext. in these patients could not be assessed because of pain. Similarly, manual evaluation of the muscle strength in the lower limbs must carry a considerable degree of uncertainty, but it was nevertheless tried (Table 5). Only 30 % of these patients had no pareses. Table 6 shows that the mobility of the spine, in terms of the finger-floor distance, is not essentially poorer than in groups I and II. In these patients too the treatment was continued according to the lines described already, but the intensity of the exercises was adapted to each individual patient's condition. In 6 patients any form of exercise therapy had to be discontinued as it increased the pain.

Summing up, the result of the evaluation 3—4 weeks after the operation was as follows:

(1) Among the patients in whom the root compression must be reasonably assumed to have been relived, there was a considerable requirement for rehabilitation in 27 %, a less marked, but definite requirement in 43 %, and no requirement in 30 %.

(2) Though varying from patient to patient, this requirement was for: (a) training the mobility of the spine, (b) training the strength of the trunk extensors, the hip muscles, and the muscles of the lower limbs, (c) massage and exercises for lengthening tender and shortened muscles.

(3) It is difficult to assess the need for physical rehabilitation in the group of patients who showed continued symptoms and signs of root irritation during the postoperative period. It is also uncertain whether exercise therapy is indicated in these cases. In a few patients, 6 of the present series, this therapy increased the pain and was, therefore, contraindicated.

B. Final Evaluation.

The previously outlined treatment was continued on an out-patient basis after discharge, when at all practicable. If the patients had their homes

too far from the department, they were encouraged to go through their exercise programme twice daily.

The mobility of the spine, as measured by the finger-floor distance, increased in all 3 groups, least in group III (table 6).

Lasegue's test had become normal (75 °—90 °) in 83 % of the patients (Fig. 6).

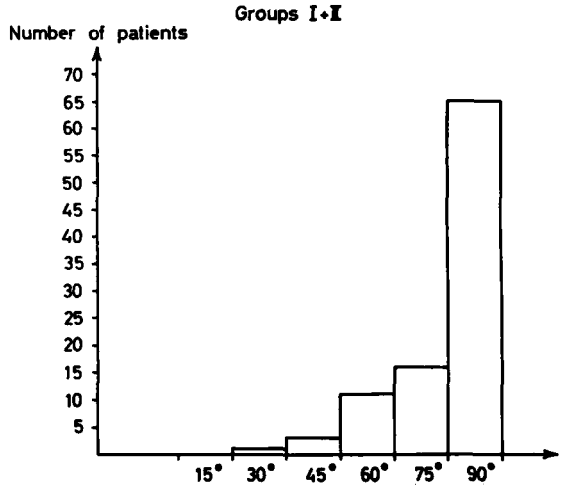

Fig. 6. Maximum elevation of lower limb with extended knee (Laségué test). Final investigation within rehabilitation period.

Strength of tr. ext., measured on the strain gauge dynamometer, had increased to an average of 85 % the normal values (Table 7).

Isometric endurance tests (Table 8) showed that now 52 % of the patients were above the 2-minute level as compared with only 8.5 % at the time of the first examination. However only 22 % exceeded the 3-minute level.

Considering the factors mentioned above, however, direct measurement of the strength of the tr. ext. on the strain gauge dynamometer as well as indirect measurement by the endurance test revealed that many patients had reduced strength. The results were compared with *Asmussen & Heebøll-Nielsen's* normal values (1961) and the normal values in Table 4. Thus, despite fairly intensive training of the trunk extensors, their strength was not normal. Perhaps the training intensity has been too slight, in respect to the extent of loading as well as the number of contractions. But it was not felt advisable to subject these

patients to greater strain, as they still have a disc lesion, although the protrusion has been removed.

Table 5 shows that despite training 24.5 % still had mild pareses and 5 % severe pareses. In other words, the attainment of normal strength in a partially denervated muscle group presumably depends mainly upon the re-innervation and not upon training of the functioning muscle cells.

Table 11. *Predominant clinical symptoms, signs, and complications during the postoperative period.*

	Number of patients	%
Stiff back	42	33,5
Thoraco-lumbar scoliosis	19	15,0
Weak trunk extensors	43	34,0
Pareses (degree $\leqq 3$)	7	5,5
Phlebitis of the lower limbs	3	2,4
Low-back pain	23	18,5
Pain in the lower limbs	33	26,5
Sphincter disturbances	1	0,8
Changes due to hyperfunction in joints, tendons and muscles	9	7,2
Lung emboli	1	0,8
Lumbar arachnoiditis	2	1,6

Table 11 sets out the symptoms and complications which predominated during the postoperative period: A stiff and weak back and pain in the legs, as well as persistent thoraco-lumbar scoliosis. The last-mentioned sign rapidly yielded in the majority of cases, but was still present, though less marked, in 4 patients at the end of the rehabilitation period. Each individual patient may be entered several times on the table, depending upon the symptoms and signs, which explains the per cent values stated.

A final statometric investigation was carried out. The two measurements could be compared in only 67 out of the 85, who were originally found to be suited. In order to make a comparison, it was demanded that the posture of the legs and of the spine as a whole (in relation to the perpendicular) must not differ by more than $\pm 2^\circ$ from that found

Table 12. *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 rehabilitation 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 13.

	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° ± 2.52	53.45° ± 4.2
Patients showing no changes in pelvic inclination ± 1° during the postoperative period 29 patients	34.76° ± 3.83	46.26° ± 5.4
Significance	P < 0.001	P < 0.001

in the first examination. Table 12 shows a significant alteration towards the normal values, not only of the pelvic tilt, but also of the lumbar lordosis. Table 13, moreover, shows that the alterations of both values occurred in patients who had shown reduced pelvic tilt and flattened lumbar lordosis at the first examination.

Table 14. *Relation between duration of disease, age at time of operation, and length of postoperative convalescence.*
Groups I + II.

Duration of disease in months	Number of weeks until patient started working	Age at time of operation
0—3	10.2	37.8
4—6	11.5	39.7
> 6	10.3	37.5

According to Table 14 the patients can return to work 10—11 weeks after the operation, regardless of the duration of their illness. The duration of illness is defined as the period during which symptoms had been constantly present before the operation. Table 15 shows that young

Table 15. *Relation between age at time of operation and length of postoperative convalescence.*
Groups I + II.

Age	Number of weeks until patient started working
15—30	9.0
31—40	10.5
41—50	11.4
51—70	11.2

patients return to work soonest after the operation, but incidentally the length of the postoperative convalescence is fairly independent of age, if only the patient is subjected to an intensive rehabilitation programme. At the end of the rehabilitation period 57 patients could return to fairly heavy physical work. 63 started on lighter physical work, while 5 received disablement pension.

The end result was as follows: 77 patients (61.6 %) were symptom free, 24 patients (19.2 %) had mild periodical complaints, while 24 (19.2 %) had constant complaints, but of varying intensity. In 8 of the latter 24 patients (6.5 %) the condition was unchanged or worse than prior to the operation.

DISCUSSION.

Should patients who have undergone operation for lumbar disc protrusions be discharged 2—3 weeks after the operation without further treatment? This question cannot be answered definitely either way, owing to the great variations in the clinical condition during the postoperative period.

The patients may be roughly divided into 3 groups: (1) Root compression relieved and no symptoms or signs originating from the discs or the soft tissue in the lumbar region or on the legs. (2) Root compression relieved, but still symptoms and signs from muscles, tendons, joints, ligaments, and discs. (3) Still symptoms and signs of lumbar root lesion at the site of the operated disc, in some cases also from the structures mentioned under (2).

The patients of the first group can be discharged without further treatment 2—3 weeks after the operation. The patients of the second group need medical supervision and physiotherapy for 2 or 3 months after the operation. On the other hand, it is questionable whether the patients of the third group should have treatment. Exercise therapy may increase their pain, and if so it is contraindicated. In my opinion cautious physiotherapy is worth trying. This is difficult to prove numerically, as any measurement, e. g. of muscle strength, carries great uncertainty because of pain-induced inhibition. According to my experience from this study, I do not agree with *Armstrong* (1951) that

any form of exercise programme to increase the suppleness of the lumbar spine is detrimental during the first 6 postoperative weeks. On the contrary, many patients certainly need it, and the exercise therapy does not give rise to pain. I also disagree with *Munro's* (1956) view that postoperative rehabilitation is equally important as the operation, if the patients are to return quickly to their work. In some cases postoperative rehabilitation may presumably shorten an otherwise long convalescence, but it probably cannot alter the end result which depends predominantly upon whether the root compression has been relieved. This is also apparent from the present study in which the result does not differ from those reported by other authors in far larger series treated without any special emphasis on postoperative rehabilitation.

On the basis of the operative results reported by 14 authors (a total of 5,175 patients) *Sparup* (1960) calculated that 82 % were »fully fit for work«.

In groups I + II of the present series 81 % were fully fit for work.

Statometric investigation revealed that during the postoperative period, the lumbar lordosis as well as the pelvic tilt change towards normal values. It is not permissible to conclude that these alterations are due to the exercise therapy, as there is no untrained control group for comparison. But it must be indicated to give exercise therapy for the purpose of supporting the spontaneous tendency to these alterations in the curvature of the spine.

Is training of the trunk extensors indicated or should these muscle groups be left alone out of regard to the disc lesion? The present study showed that many patients have considerably reduced strength in the trunk extensors. This reduction in strength may be due to neurogenous atrophy *(Knutsson* 1961, *Mack* 1951, *Weddell et al.* 1944) or to atrophy of disuse. Training increases muscle strength and seldom gives rise to complaints, so it seems to be indicated.

CONCLUSION AND SUMMARY.

Clinical evaluation of 125 patients 3—4 weeks after operation for lumbar disc protrusion showed that about 70 % of those patients whose root compression had been relieved seemed to be in need of post-

operative rehabilitation. In other words, at a time long after the majority of patients have been discharged from the neurosurgical department they are in need of medical supervision and treatment. If a training programme is carried out, the length of postoperative convalescence appears to be independent of the duration of symptoms before the operation and partially independent of age. However, the youngest patients appear to get back to work sooner than others.

Determination of the strength of the trunk extensors showed definite reduction of strength in many cases. During a rehabilitation period there was a considerable increase in strength which, however, remained below normal in several patients.

In the group of patients, who postoperatively have symptoms and signs indicating persisting root lesion, it is difficult to assess the need of rehabilitation and it is highly individual. In 6 cases any form of exercise therapy had to be discontinued. The end result was 61.6 % symptom free, 19.2 % having mild, periodical complaints, and 19.2 % having persisting symptoms including 6.5 % in whom they were unchanged or worse. This does not differ from the results reported by others in far larger series. Presumably, therefore, postoperative rehabilitation does not alter the end result for each individual patient. However, physical rehabilitation will no doubt often shorten an otherwise long postoperative convalescence. But even though these patients were left untreated, everyday demands, though more slowly, would render them »fully fit for work«.

These aspects might be further elucidated by a follow-up study on an untrained group of patients.

II

FOLLOW-UP ON A TRAINED AND AN UNTRAINED GROUP OF PATIENTS

INTRODUCTION.

The prognostic role of postoperative rehabilitation in lumbar disc protrusions and its indications are still being discussed.

According to some authors, any form of exercise therapy during the postoperative period is absolutely detrimental, as the aim must be fibrous ankylosis at the site of the operated disc. Consequently, they avoid any form of exercise therapy *(Armstrong* 1951), and others even use immobilization in a corset *(Kristiansen* 1961). Others again are completely indifferent and discharge the patients after the operation without further treatment *(Poppen* 1945, *Spurling & Grantham* 1949, *Woolsey & Tsang* 1952).

At the other extreme, there is *Munro* (1956) who considers postoperative treatment equally important as the operation, if the patients are to return to work quickly. *O'Connel* (1951), *Keijser* (1961), *Aldes* (1952), *Anderson et al.* (1961) also stress the importance of active rehabilitation during the postoperative convalescence. It is characteristic of a number of the above-mentioned authors, however, that their attitude for or against postoperative rehabilitation is rigid and generalizing.

Hansen (1964) tried to evaluate the need of postoperative rehabilitation, quantitatively as well as qualitatively, by examining 125 patients 3—4 weeks after the operation and at the end of the rehabilitation period, 2 or 3 months after the operation.

The result was as follows: (1) In about 70 % of those patients whose root compression had been relived by the operation, i. e. patients who were cured, there was a need of rehabilitation (great in 27 % and lesser, though undoubted in 43 %). The remaining 30 % were not found to be in definite need of rehabilitation.

(2) If the patient went through a rehabilitation programme, the length of the postoperative convalescence was independent of the duration of symptoms and partially independent of age at the time of operation. However, the youngest patients returned first to work.

(3) The end result (61.6 % symptom free, 19.2 % with periodical mild complaints, and 19.2 % with constant complaints of varying intensity, including 6.5 % who were unchanged or worse) did not differ from the results, which have been reported in follow-up studies of far larger series in which no particular stress has been laid on rehabilitation.

It was concluded, then, that postoperative rehabilitation presumably shortened the postoperative convalescence period, but did not alter the end result. Lastly, it was emphasized that a study of an untreated series would elucidate this question.

The present study was then undertaken with the following aims:

(1) Follow-up of the treated group.

(2) Follow-up of a group which had received no postoperative rehabilitation and comparison of these 2 groups.

MATERIAL.

Treated group: Originally, this group comprised 125 patients admitted to the Department of Physical Medicine, Rigshospitalet, during the period 1956—1960. None of them had previously undergone operation for lumbar disc protrusion. The operation was performed in the Department of Neurosurgery, and about 8 days later the patients were transferred back to the Physical Medicine Department where they had postoperative rehabilitation. At follow-up, however, 10 of the 125 could not be traced. A total of 106 were examined and 9 completed a questionnaire.

Untreated group: Patients operated upon in the Department of Neurosurgery, Rigshospitalet, during the period 1953—55. This group is characterized by:

(1) having been discharged or transferred to other departments about 10—15 days after the operation,

(2) not having had postoperative rehabilitation after the discharge from the neurosurgical department (massage, short-wave diathermy, and hot dressings are not taken to constitute rehabilitation),

(3) no patients but 3 had previously had operations for lumbar disc protrusions *(vide infra).*

This group primarily comprised 163 patients, but out of this number 9 had died, 8 could not be traced in the National Registry, 10 refused to attend follow-up, 5 had gone abroad, and one patient had to be excluded as he had received prolonged rehabilitation. This leaves 130 patients (127 of whom were examined and 3 sent replies to a questionnaire).

The age distribution and sex ratio will be seen from Table 1.

Table 1. *Age distribution and sex ratio.*

	No. of patients					
	Trained			Untrained		
Group	I	II	III	I	II	III
15—20 years	1	0	0	0	0	0
21—30 years	8	1	3	12	3	4
31—40 years	38	9	11	31	10	9
41—50 years	11	5	11	25	8	4
51—60 years	4	4	7	14	5	5
61—70 years	0	1	1	0	0	0
Total	62	20	33	82	26	22
females / males	34 / 28	10 / 10	19 / 14	31 / 51	11 / 15	12 /10

Table 2. *Operative findings.*

	No. of patients	
Level of protrusion	Trained	Untrained
Lumbar vertebrae II / III.....	0	3
Lumbar vertebrae III / IV	3	9
Lumbar vertebrae IV / V.....	61	69
Lumbar vertebra V / sacral I	55	61
Total	119*	142**

* 4 patients had 2 slipped discs.

** 12 patients had 2 slipped discs.

Table 3. *Preoperative X-ray findings.*

	No. of patients	
	Untrained group	Trained group
No abnormality	52 (38.5 %)	54 (44.5 %)
Mild degenerative changes of the lumbar spine	77 (57.0 %)	60 (49.0 %)
Severe degenerative changes of the lumbar spine	6 (4.5 %)	8 (6.5 %)

X-ray report not available for 6 cases of the untrained group.

X-ray report not available for 3 cases of the trained group.

The patients of group I are symptom free. Those of group II have periodical, mild complaints from the lumbar region and/or the legs. The patients of group III have constant complaints, but of varying intensity.

The operative findings are listed in Table 2.

The duration of symptoms before operation was 5.7 months in the trained group and 7.4 months in the untrained group. The duration is taken to be the period of constant symptoms. The follow-up period after the operation averaged 25.5 months in the trained group and 52 months in the untrained.

Preoperative X-rays of the lumbar spine showed no major differences between the 2 groups (Table 3).

Before starting on any comparisons between the two groups, it must be ascertained whether they are comparable.

All the patients had their operations in the same neurosurgical department within a fairly short space of time, so the operative indications must be assumed to have been the same for both groups.

The age distribution is almost identical.

The radiological changes in the lumbar spine are of the same severity in both groups.

The trained group consists of 48 % males and 52 % females, the untreated group of 58.5 % and 41.5 % respectively. *A priori,* the operative results would appear to be indpendent of sex. According to *Sparup* (1960), however, females have a poorer prognosis. Others *(Busch et al., Tørma, Gurdjian et al.)* who have published larger series, do not mention a poorer prognosis for women. Therefore, the difference between the sex ratio in the two groups is probably not of major importance in assessing the prognosis.

The average duration of symptoms is shorter in the trained than in the untrained group. This is possibly of importance in comparing the length of the postoperative convalescence and the need of rehabilitation. In a series with a long follow-up period *Gottschalk & Højgård* (1961) did not find definite differences between groups with a long and a short duration of symptoms. It is unlikely, therefore, that the groups are incomparable in respect to prognosis owing to the named difference in the duration of symptoms.

The follow-up period is considerably shorter for the trained than for the untrained group. This is of significance in assessing the end result, but not in evaluating the need of postoperative rehabilitation. No patient of the trained group had previously undergone operation for

lumbar disc protrusion. Three patients of the untrained group had a history of such previous operation, but they were included since the operation concerned, i. e. the re-operation, had been performed after a symptom-free interval, so that the protrusion must be interpreted as a new protrusion.

All considered, it must be concluded that the groups are not fully comparable in every respect, but that the named differences are small and their significance so uncertain that a comparison is nevertheless justified.

METHODS.

(1) The patients of both groups were subjected to an ordinary clinical examination, including manual testing of the muscle strength in the legs, in particular also of the gluteal muscles.

(2) The strength of the trunk extensors was determined:

(a) indirectly by determining the isometric endurance of the trunk extensors. This test has been described in detail by Hansen (1964). The patients lay on a vaulting horse, the upper part of the body protruding over its edge, supporting on their hands. The edge of the horse was on a level with the upper margin of the iliac crest. The legs were fixed by straps. Thereupon, the time that the patient could keep the upper part of his body horizontal, with his arms crossed over his chest, was determined.

(b) Directly by means of a strain gauge dynamometer. Fig. 1 (see p. 14) illustrates by dynamometer, Fig 2 (see p. 15) the test. The result was recorded automatically on a self-balancing recorder (Philips PR 2210/P/00). After 5 contractions the maximum result was recorded and taken to represent the isometric strength of the trunk extensors. This test was only performed in the trained group, as the apparatus was not available in the department when the patients of the untrained group were examined.

(3) The patients of the trained group also had statometric examination by the method of *Mølhave (Mølhave* 1958). This test measures the spatial orientation of legs, pelvis, spine, trunk, and head in relation to the perpendicular.

RESULTS.

In the untrained group, operated upon about 4 years before follow-up, it is of course difficult to assess with any certainty the need for rehabilitation during the postoperative period. This item was, therefore, studied only in the group of patients who were cured by the operation, i. e. the group whose symptoms during the postoperative period were presumably not caused by persisting root compression. These patients were questioned in detail regarding their condition during this period. Nevertheless, the evaluation of a need for treatment can only be approximate.

From Table 4 it may be seen, that approx. 24 patients (22 % of the patients of groups I + II) were estimated to have been in any major need of rehabilitation.

Evaluation of the trained group 3—4 weeks after the operation had shown that 27 % of the patients, who were cured, were in major need

Table 4. *Patients who presumably needed, but did not receive postoperative training.*

Untrained group.

Groups I+II: A total of 24 patients.

Group		I+II
Age	neglected group	41.9
	remaining patients	40.7
Duration of disease in months	neglected group	11.1
	remaining patients	6.9
No. of weeks until pts. returned to work.	neglected group	24.8
	remaining patients	10.5
♀/♂		8 / 16
Physical work / non physical work		12 / 12

Table 5. *Relation between duration of disease, age at operation, and length of postoperative convalescence.*

Group I + group II.

	Trained group		Untrained group	
Duration of disease in months	No. of weeks until pts. returned to work	Age	No. of weeks until pts. returned to work	Age
0—3	10.2	37.8	10.5	40.5
4—6	11.5	39.7	13.0	41.5
> 6	10.3	37.5	18.0	38,0

of rehabilitation (pag. 23). Accordingly, the ned of rehabilitation was within the same range in both groups.

Table 4 shows, moreover, that the patients are characterized by long postoperative convalescence and a long duration of symptoms, while in age they do not differ much from the remaining patients of the same groups. If the duration of symptoms is related to the length of the postoperative convalescence (Table 5), it will be found that the trained patients were working again 10—12 weeks after the operation, irrespective of the duration of symptoms, while this does not apply to the untrained patients. The longer convalescence period in the untrained group is not due to a more advanced age.

Table 6. *Testing of muscular strength of lower limbs.*

	No. of patients			
	Trained group		Untrained group	
No pareses	79	75,2 %	96	76,0 %
Mild pareses degree 4	22	21.0 %	23	18.5 %
Rather severe pareses degree 0—3	4	3.8 %	7	5.5 %

Trained group: 3 patients only answered a questionnaire and 1 could not be evaluated because of pain.

Untrained group: 9 patients only answered a questionnaire and 1 could not be evaluated because of pain.

Table 7. *Finger-floor distance in cm.*

	Trained	Untrained
Group I	6	8
Group II	12	15
Group III	21	35

Manual testing of muscle strength at follow-up did not reveal major differences between the 2 groups.

Presumable, therefore, the muscles which can be trained, will be trained by the doings of everyday life.

The suppleness of the hip joint and lumbar spine was assessed by the distance between the finger tips and the floor in forward flexion with extended knees. The values are seen to be in the same range in the trained and untrained group (Table 7) except in patients who had constant complaints (Group III); in this category of patient the untrained group was less supple.

Indirect determination of strength in the trunk extensors by means of the isometric endurance test showed, that among the untrained group

45 % had values below 2 minutes and 69 % below 3 minutes. In the trained group only 14.5 % were below the 2-minute level, while 50 % were below the 3-minute level. Overweight patients (weight > normal weight + 20 %) were left out of both groups (Table 8). Comparison with normal values (Table 9) shows that insufficiency of the trunk extensors was found in many patients of both groups, but in a larger number in the untrained group.

Direct determination of strength in the trunk extensors, as described previously, showed (Table 10), that despite postoperative rehabilitation, the strength of the trunk extensors was an average of 25 % below the

Table 8. *Isometric endurance test for trunk extensors. Groups I+II.*

	No. of patients	
Minutes	Trained	Untrained
0—1	4	19
1—2	6	22
2—3	25	21
3—4	12	14
> 4	22	14

Trained group: 11 patients were not tested (2 overweight).
Untrained group: 11 patients were not tested (7 overweight).

Table 9. *Isometric endurance test for trunk extensors.*

Normal values	
168 persons	(83 men + 85 women)
Minutes	Number of persons
0—1	0
1—2	8
2—3	29
3—4	25
≧ 4	106

Table 10. *Strength of trunk extensors at follow-up Trained group*

		No. of patiens		
	Mean	Normal value ÷ 2d>	Normal value 2d±	Normal value + 2d<
Group I + II	55.7 kg	29	45	1
Normal value	73.1 kg			

d: ♂: 14.5 %
♀: 17.7 %

7 patients were not tested.

Table 11. *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

Table 12. *Result of treatment.*

	No. of patients			
	Trained group		Untrained group	
Group I	62	54.0 %	82	63.0 %
Group II	20	17.5 %	26	20.0 %
Group III				
Unchange of worse	8	7.0 %	6	4.6 %
Improved	25	21.5 %	16	12.4 %

normal values calculated on the basis of the values stated by Asmussen et al. (1961).

Statometric examination (Table 11) showed, that the pelvic tilt as well as the lumbar lordosis had remained unchanged from the values found at the end of the postoperative rehabilitation period. During this period a significant alteration had occurred in patients, who had shown a low pelvic tilt and a flattened lordosis at the first statometric examination (3—4 weeks after the operation). (pagina 25).

Table 12 sets out the end results, which are seen to be somewhat better in the untrained than in the trained group. 71.5 % in the trained group and 83 % in the untrained group being fit, despite the fact that the follow-up period is longer in the untrained group. In both groups 93 % had improved. However, the groups comprise only a moderate number of patients, so the findings do not justify the definite conclusion that postoperative rehabilitation makes the prognosis poorer. But anyway, there was no question of an improved prognosis. The values are in the same range as in other, much larger series *(Busch et al.* 1949, *Lindgren* 1949, *O'Connel* 1950, *Gurdjian et al.* 1961).

Postoperative rehabilitation also does not seem to improve the earning capacity of the male patients. In the untrained group 80.5 % were in unchanged or better financial circumstances as against 73 % in the trained group. 8 males of the trained group and 11 males of the untrained group had to change from heavy physical work to lighter physical work.

DISCUSSION.

The result of this follow-up study shows that postoperative rehabilitation does not improve the prognosis.

This raises the question whether the treatment was sufficient. I feel I can assert that is was. An effort was made to give all the patients a therapy as active as possible, paying due regard to their condition. In training the muscles, the principle was to increase the loading and the number of contractions as far as possible.

What, then, can be demanded of rehabilitation? Presumably only a shortening of the postoperative convalescence in patients, who postoperatively prove to be in major need of rehabilitation.

Which factors influence the postoperative course in patients, whose root compression has been relived by operation? Patients with lumbar disc protrusions, especially those with slow progression of the disease and moderate intensity of symptoms, often have had a prolonged fixation of the thoraco-lumbar spine due to the pain. Frequently, they have developed scoliosis and secondary tender fibrositis of the lumbar and gluteal muscles.

Furthermore, the root compression often causes, in addition to the well-known symptoms distally in the legs, neurogenous atrophy of the sacrospinal and gluteal muscles. *Knutsson* (1961), *Mack* (1951), and *Weddell et al.* (1944) have demonstrated denervation potentials in the erector spinae muscles.

It is an old observation that disuse and immobilization of a muscle group rapidly leads to atrophy. Incidentally, this has been demonstrated experimentally by *Hettinger* (1961). This applies quite particularly if there is a lesion eliciting pain in the immediate vicinity. Patients with lumbar disc protrusions have often been bedridden for several weeks before the operation and show marked fixation of the lumbar column due to the pain. In a number of these patients, therefore, the trunk extensors have undergone atrophy of disuse.

Together and separately, the named factors may influence the postoperative condition and the need of rehabilitation.

Does the duration of symptoms influence the length of postoperative convalescence? Perhaps. In the untrained group a long duration of symptoms was found to entail a long convalescence period. This does not apply to the trained group, presumably because of the postoperative rehabilitation. Quite apart from rehabilitation, if any, early operation

ought to bring the patients sooner back to work. But there does not seem to be agreement on this item. According to *Dahlgren* (1963) early operation does not make for essential shortening of the convalescence, while *Hirsch* (1958) is of the opposite opinion. In a previous study, however, *Hirsch* (1949) found that 97 % of the patients were working 4 months after the operation, although they had been having symptoms for several years before the operation. *Dahlgren's* patients had only had symptoms for an average of 2 weeks, and none over 6 weeks; out of those who were cured 21 % had not returned to work in 4 months despite the short history. Possibly, this very group of patients has been in need of postoperative rehabilitation.

In the untrained as well as the trained group of the present material 20—25 % were in major need of rehabilitation of the same order of magnitude as must have been presumed to exist in *Dahlgren's* series.

Summing up, it may be concluded that *ceteris paribus* a long duration of symptoms will presumably predispose to a long convalescence period and an increased need of rehabilitation, while a short duration of symptoms is by no means tantamount to a rapid return to work.

Many patients of both groups appeared to have a reduced strength in the trunk extensors. Measurement of the isometric strength revealed a reduction by about 25 % in the trained group. This is perhaps the explanation of the sensation of fatigue in the lumbar region which is a complaint in so many cases of disc protrusion.

CONCLUSIONS AND SUMMARY.

A total of 245 patients who had undergone operation for lumbar disc protrusion were followed up. Of these patients 115 had been through a rehabilitation programme during the first 2—3 months after the operation. The remaining 130 had not received such postoperative treatment. From a comparison of these 2 groups it may be concluded:

(1) Postoperative rehabilitation of patients operated upon for lumbar disc protrusion does not appear to improve the end result.

(2) It is estimated that a major need of rehabilitation exists in 25 % of the patients in whom the root compression has been relieved, i. e. in those who have been cured by the operation.

(3) Rehabilitation will presumably shorten the postoperative convalescence period.
(4) Despite postoperative rehabilitation the isometric strength of the trunk extensors is reduced by about 25 %. Determination of the strength was done by a strain gauge dynamometer. Assessed by an isometric endurance test many patients also showed insufficiency of the trunk extensors.
(5) Statometric examination of the trained group showed, that the normalizing alterations of the pelvic tilt and of the lumbar lordosis, seen during the first 2—3 months after the operation, were permanent.

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