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Physical Measurements as Risk Indicators for Low-Back Trouble Over a One-Year Period

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Of all 30-, 40-, 50-, and 60-year-old inhabitants of Glostrup, a suburb of Copenhagen, 82% (449 men and 479 women) participated in a general health survey, which included a thorough physical examination relating to the lower back. The examination was constituted of anthropometric measurements, flexibility/elasticity measurements of the back and hamstrings, as well as tests for trunk muscle strength and endurance. The reproducibility of the tests was found to be satisfactory. Twelve months after the physical examination 99% of the participants completed a questionnaire sent by mail concerning low back trouble (LBT) in the intervening period. The prognostic value of the physical measurements was evaluated for first-time experience and for recurrence or persistence of LBT by analyses of the separate measurements and discriminant analyses. The main findings were that good isometric endurance of the back muscles may prevent first-time occurrence of LBT in men and that men with hypermobile backs are more liable to contract LBT. Recurrence or persistence of LBT was correlated primarily to the interval since last LBT-episode: the more LBT, the shorter the intervals had been. Weak trunk muscles and reduced flexibility/elasticity of the back and hamstrings were found as residual signs, in particular, among those with recurrence or persistence of LBT in the follow-up year. [Key words: low-back trouble, general population, prognostic factors, first-time occurrence, recurrence]

STANDARDIZED PHYSICAL EXAMINATIONS relating to the back have been included in few studies on low-back trouble (LBT) in general populations[31,86,87] and none has been longitudinal in its design. Thus an identification of objective risk indicators for LBT, based on physical measurements, has not been possible either for first-time experience or for recurrence or persistence of LBT.

The aim of the present study was to begin to fill this gap in knowledge. Over a one-year follow-up period, an investigation was made as to whether indicators of prognostic value for LBT could be identified via various anthropometric measurements, elasticity and flexibility measurements of the hamstrings and back, and trunk muscle strength and endurance tests, either separately or combined.

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POPULATION AND METHODS

Population and Design. Of all 30-, 40-, 50-, and 60-year-old inhabitants in the Municipality of Glostrup (a suburb of Copenhagen, Denmark), 82% (449 men and 479 women) participated in a general health survey. This included an extensive examination relating to the lower back, with both questionnaires and physical measurements.[14-16,18] The participants were not informed beforehand that the health survey would focus specifically on the lower back.

Twelve months after the examination, 99% of the population examined (442 men and 478 women) completed a follow-up postal questionnaire, especially concerning LBT in the intervening period. Fifty participants gave the follow-up answers by telephone.[16]

A detailed description of the general study design and a discussion of the representativeness of the population and characteristics of the nonparticipants have been published previously.[16] In brief, the population can be considered representative of Copenhagen County. Nonparticipants were more common among unmarried persons. The general morbidity among nonparticipants did not seem to differ from that of the participants to any appreciable degree.

Delimitation of LBT. In all questionnaires, questions about the occurrence of LBT were phrased as follows: "Have you/ever/within the last twelve months/had pain or other trouble with the lower part of your back?" LBT in relation to menstruation alone was excluded.[16] The reproducibility of the history of LBT thus obtained has been discussed in a separate paper.[18]

In this study,[15] the lower back was demarcated anatomically as suggested by Anderson:[5] the area between the lower costal margins and the gluteal folds.

Physical Measurements. Body height and weight were measured by a laboratory technician, while the rest of the physical examination shown in Table 1 was carried out by the author. The examination always took place between 8:00 AM and 1:30 PM and lasted 20–30 minutes for each participant. All participants went through the same examination sequence as laid down in a written instruction. The physical examination was conducted without knowledge of the participant's previous experience of LBT.[16]

The physical measurements listed in Table 1 were made as follows:

The *maximal isometric strength* was measured for attempted backward extension and forward flexion of the trunk. The participant was standing in stockings or bare feet on a nonslip material and with front (or back) against an adjustable supporting board, so that the upper edge of the board was at the level of the iliac crests. A wide canvas strap was tightened around the shoulders at the lower

Table 1. The Sequence of Measurements Carried Out at the Initial Examination. (Compound parameters are given below. For further details, see text)

Measurements	*Abbreviation*
Standing height (without shoes) (cm)	HEIGHT
Weight (in underwear and dressing gown) (kg)	WEIGHT
Maximal voluntary contraction (MVC) at isometric backward extension of the trunk (N)	EXTENSION
Maximal voluntary contraction (MVC) at isometric forward flexion of the trunk (N)	FLEXION
Leg length inequality (in 1/2 cm)	LEGINEQ
Fingertip-floor distance (cm)§	FINGERFLOOR
Modified Schober test (mm)	SCHOBER
Trunk-raising test (4 grades)§	SITUP
Leg-lowering test (6 grades)§	LEGLOW
Length of the hamstrings, method I (in 5 degrees)	HAMSTR-I
Length of the hamstrings, method II (in 5 degrees)§	HAMSTR-II
Femur epicondylar width (mm)	EPICON
Leg length (cm)	LEGLENGTH
Isometric endurance of the back muscles (seconds)	ENDURANCE

Compound parameters: HEIGHT − LEGLENGTH = UPBODY; (WEIGHT × 10^5)/($HEIGHT^3$) = ROHRINDEX; FLEXION/EXTENSION = FLEXEXT.

For those parameters marked with § lower values indicate higher degree of elasticity or larger strength.

attachment of the deltoid muscle[8] and horizontally through a chain connected with a strain-gauge dynamometer that also was height-adjustable. These were connected to a measuring bridge and a pen-recorder. The participant was instructed not to use the arms for support while the measurements were made. During each task, the participant was asked to increase the pull gradually for a few seconds and again to relax after reaching the maximum. Peak values obtained by short jerks were excluded. Each test included at least three maximal contractions at intervals of at least 10 seconds. If the highest value was reached at the third attempt, additional contractions were requested until a decrease in performance was recorded. The maximal value was registered as the maximal voluntary contraction (MVC). All attempts were recorded on paper. The dynamometer equipment was calibrated against known weights. It was tested for linearity up to 140 kg (1373 N), and daily calibrations were performed up to 70 kg (687 N). The MVC measurements were not carried out for the first 14 participants at the initial examination; for another 11 participants the measurements could not be used for technical reasons.

Possible *leg length discrepancy* was evaluated by determination of the level of the pelvis in an upright position with the knees fully extended and the feet flat on the floor. The evaluation was made with a device that incorporates a spirit level with adjustable arms resting on the iliac crests. This is similar to the method described by Hirschberg and Robertson.[32] If the iliac crests were out of level, wooden boards down to 0.5 cm in thickness were placed under the foot on the short side until level.

Fingertip-floor distance was measured from the tips of the middle fingers while the participant, in stockings or bare feet, was bending maximally forward with the feet together and the knees straight. A metal-ended tape-measure was used, and the measurement was judged to the nearest whole cm.

The *Schober test*[73] for anterior spinal flexion was modified in accordance with Macrae and Wright.[49] While the participant stood erect with feet flat on the floor, a mark was inked on the skin at the spinal intersection of a line joining the dimples of Venus. Further marks were inked 5 cm below and 10 cm above the first mark, the distances being determined by a metal-ended tape-measure pressed against the skin. The participant was then asked to bend forward maximally, and the distance between the upper and the lower mark was again measured. The increase in mm was recorded.

In agreement with Kendall et al[42] the *trunk raising test* was carried out with the participant supine and the legs extended. The dynamic strength of the trunk flexor muscles was tested by the performance of a complete and slow curled-trunk sit-up. The load was decreased by changing the arm position from hands behind the head ("normal," grade 1), to forearms across the chest (grade 2), to forearms extended forward (grade 3). Participants who were unable to perform any of these tests were given grade 4.

The *leg-lowering test*[42] was performed with the participant in the supine position, with the hands placed up beside the head. The legs were raised straight to 90° hip flexion. To grade the strength of the abdominal muscles, the participant was asked to lower the legs slowly, and at the moment the pelvis started to tilt anteriorly and/or the low back started to arch from the couch the angle between the extended legs and the couch was noted. The angle was read off from a big scale protractor on the wall with the degrees marked up to 90° (Figure 1). Before each measurement, the participant was placed with the hip-joints opposite the zero-point of the protractor on the wall. The following grading was used: grade 1: 0°; grade 2: ≤ 15°; grade 3: ≤ 30°; grade 4: ≤ 45°; grade 5: ≤ 60°; grade 6: > 60°.

Two tests for the *length of the hamstring muscles* were carried out:

Method I. A modification of the straight leg raising test with the low back flat on the table.[39] The angle of the maximal hip flexion with extended knees was recorded to the nearest degree with 0 or 5 as the final digit. Recordings were made up to 80° only, as this is considered normal,[39] viz, the lower the degree measured, the tighter were the hamstrings. The angles were read from the same

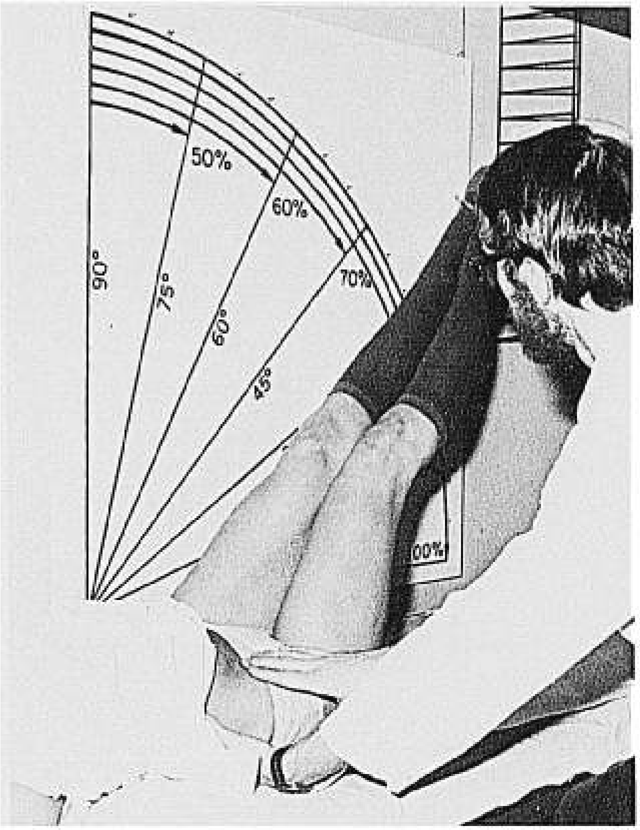

Fig 1. Leg-lowering test performed by reading off the angle between the extended legs and the couch from the large scale protractor on the wall.

wall protractor as described above (Figure 1). A modification of the test[39] was performed when the hip flexor was found to be tight.

Method II. With the participant supine and the hip flexed to 90° from the horizontal, the range of restricted extension in the knee joint was measured[33,66,67] to the nearest degree with 0 or 5 as the final digit; the higher the degrees recorded, the tighter were the hamstring muscles. This measurement was carried out with a goniometer consisting of the arm of a plastic standard goniometer[55] with a protractor (0°–180°) connected through a junction allowing free movement to a metal pointer with a weight in the end (Figure 2). The pointer arm was kept parallel to the vertical femur and the other goniometer arm parallel to the tibia, thus permitting

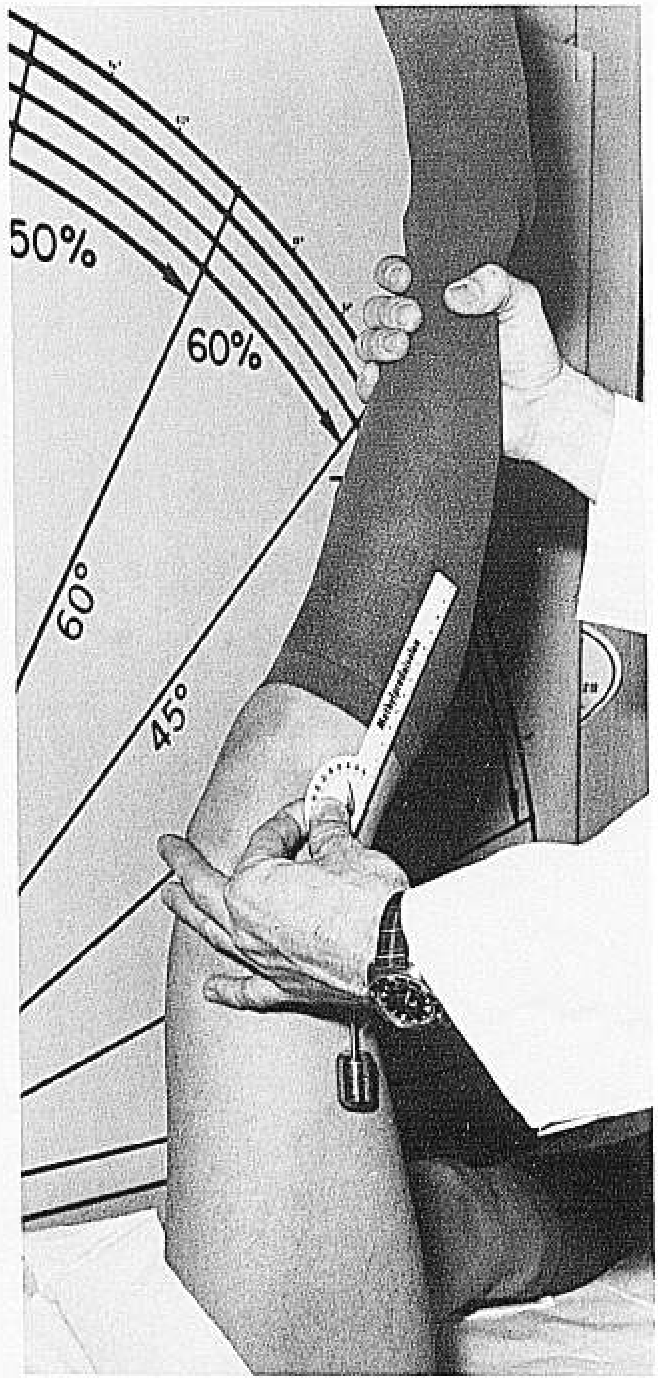

Fig 2. Measuring the length of the hamstring muscles (method II) using a specially designed goniometer (cf, text).

reading of the angle at the level of the knee joint. This measurement was not carried out in the first 14 participants in the initial examination.

The *femoral epicondylar width* (greatest linear width) was measured on the right side with the participant in the supine position. A special caliper was used, and the measurement was done to the nearest whole mm.

The *leg length* was measured on the right side as the distance from the anterior superior iliac spine to the lower border of the medial malleolus. The measurement was taken using a metal-ended tape-measure with the participant in the supine position. Recordings were made to the nearest whole cm.

The *isometric endurance of the back muscles* was evaluated by measuring how many seconds (up to 240 seconds) the participant was able to keep the unsupported upper part of the body (from the upper border of the iliac crest) horizontal while placed prone with the buttocks and legs fixed to the couch by three wide canvas straps, and the arms folded across the chest. The test was continued until the participant could no longer control his posture or until he reached his limit for tolerance of symptoms of fatigue.[17,28,82]

From these measurements the following compound parameters were calculated:

Length (cm) of the *upper part of the body* (UPBODY), ie, standing height minus the leg length.

Rohrer's index (ROHRINDEX) (ie, weight in g x 100/height in cm^3).[37,38]

Flexion/extension ratio (FLEXEXT), ie, MVC at forward flexion divided by MVC at backward extension.

METHOD OF DATA ANALYSIS

The data were transferred to an SPSS (Statistical Package for Social Sciences) data base.[59]

Reproducibility of Measurements. Repeatability analyses were carried out either within one day or with a few days' interval in motivated persons. For the physical measurements the coefficient of variation was calculated (CV = SD/Mean) when suitable.

In a subsample of 127 participants the modified Schober test, the fingertip-floor distance, the length of hamstring muscles (method II) and the MVC at attempted forward flexion and backward extension were carried out twice. Reexamination was made within an interval of six to seven months (median 29 weeks, range 20–59 weeks).[18] In addition in 71 participants the MVC measurements were repeated one to two months (median 49 days, range 8–236 days) after the initial examination. Chi-square tests, Student *t* tests, and analyses of variance were used in the evaluation of the test-retest reproducibility.

Prognostic Value. The predictive value of the physical measurements has been evaluated. This was done by comparing the obtained values of the measurements for those who had their *first* experience of LBT in the follow-up year (F-LBT) with those who had *never* had LBT and did not get it during the follow-up year (N-LBT) (cf. Table 2). A corresponding set of comparisons was made between those with LBT *previously* but not during the follow-up year (P-LBT) and those with *recurrence* or persistence of LBT in the follow-up year (R-LBT). In all analyses, the effect of age and sex was studied.

The measurements were used in the analyses only if they could be obtained in a proper way—which was not possible, for instance, for certain participants with sequelae after poliomyelitis, cerebral palsy, broken leg, arthrodesis, alloplastic operation, or severe kyphoscoliosis, or for pregnant women. The various muscle tests were utilized in the analyses only when they could be carried out without causing pain.

Analyses of the Separate Measurements. The prognostic value of the separate measurements was estimated as described above by using chi-square test, Mann-Whitney rank sum test corrected for

Table 2. Distribution of Participants in Relation to their Answers Concerning Low Back Trouble (LBT) up to the Day of Examination and in the Follow-Up Year

		LBT before or at the examination day					
		Yes			No		
		Men	Women	Total	Men	Women	Total
LBT in the follow-up year	Yes	170	185	355(R-LBT)	28	30	58(F-LBT)
	No	106	108	214(P-LBT)	138	155	293(N-LBT)
Total		276 + 5*	293 + 1*	569 + 6*(LBT-Y)	166 + 2*	185	351 + 2*(LBT-N)

*The eight participants who did not complete the follow-up questionnaire. R-LBT: *recurrence* or persistence of LBT in the follow-up year. F-LBT: *first time* experience of LBT in the follow-up year. P-LBT: *previous* LBT, but not in the follow-up year. N-LBT: *never* had LBT. LBT-Y: *Yes* LBT prior to the day of examination. LBT-N: *No* LBT prior to the day of examination.

ties, and Student *t* test. For analyses of age differences the chi-square test, Kruskal-Wallis test corrected for ties, and analysis of variance were used.

The anthropometric measurements are less changeable with time and low-back events and, therefore, have also been tested in relation to whether a participant had ever experienced LBT, (Yes/No), ie, the totals in Table 2 (LBT-Y/LBT-N). Whether body weight should be included in this connection might be disputable, though in the subsample examined at a 6–7 month interval, the average difference was insignificant (0.06 kg).

Discriminant Analyses. In addition to the analyses of the separate measurements, stepwise discriminant analyses[65,85] have been made including all measurements. Thus the aim was to determine whether the measurements, either separately or in some combination, could discriminate between the groups under consideration.

The analyses for recurrence or persistence of LBT were carried out with one extra variable included—number of weeks since the participant last experienced LBT (LBTLAST)—because this particular parameter is known to have a strong correlation with recurrence of LBT.[14]

Each particular analysis was carried out only with those participants for whom all parameters in question were known.

RESULTS

Reproducibility of Measurements

Table 3 gives the coefficient of variation for those measurements for which such a calculation was suitable. In one male subject, the isometric endurance of the back muscles was tested five times within ten days; the mean endurance time was 120 seconds and the coefficient of variation 7%.[17]

The *modified Schober test* was carried out twice on 127 participants, ie, at the initial examination and the six-month follow-up. An increase in flexibility was found at the second examination corresponding to 2.3 mm (from 65.6 mm to 67.9 mm; SD [of the difference] = 7.19 mm), which was statistically significant (t = −3.65, df = 126, $P < 0.001$). Without an out-lier difference of 43 mm (a man with acute LBT at the initial examination), the mean increase was 2.0 mm (66.0 mm to 68.0 mm; SD [of the difference] = 6.23 mm, t = −3.62, df = 125, $P < 0.001$).

Table 3. Coefficient of Variation (CV) Calculated for the Listed Measurements

Measurement	Number of Observations	Number of persons	Mean	CV (=SD/Mean)
LEGLENGTH	19	6	89 cm	0.44%
EPICON	24	7	89 mm	0.38%
SCHOBER	25	5	67 mm	4.83%
FLEXION	26	13	581 N	6.35%
EXTENSION	28	14	762 N	4.72%

The *fingertip-floor distance* was measured at both the initial and the six-month follow-up examination on 126 participants. For one man, the test could not be carried out at the second examination because of knee pain. For 73 participants the test was zero cm on both occasions. In eight instances, the measurement was zero cm on one of the two occasions: five at the initial examination and three at the follow-up. For the remaining 45 participants the mean-difference between the two measurements was 1.43 cm (15.96 cm–14.53 cm; SD = 8.52 cm), which is not statistically significant; and with exclusion of an outlier difference of 44 cm (the same participant as above) the mean-difference was 0.46 cm (15.07 cm–14.61 cm; SD = 5.57 cm). Altogether, 50 participants presented two different values: of these, 24 were lower and 26 higher at the initial than the six-month follow-up (24 vs. 26: $\chi^2 = 0.080$, df = 1, $P = 0.78$).

The *length of the hamstring muscles* (method II) was measured twice on the right side in 121 participants and on the left side in 119. No trends were found towards increased or decreased length of the hamstrings. The mean-differences were 0.3° and 0.7° on the right and left side, respectively, and these were not statistically significant. On the right side, 46 participants presented a lower and 35 a higher initial value (46 vs. 35: $\chi^2 = 1.49$, df = 1, $P = 0.22$), while 40 presented the same value at both examinations. On the left side, the initial value was lower in 40 cases, higher in 39 (40 vs. 39: $\chi^2 = 0.013$, df = 1, $P = 0.91$), and unchanged in 40.

Table 4 summarizes the results on the reproducibility of *MVC at attempted forward flexion and backward extension* of the trunk. To investigate the observed differences between the mean-values obtained on the three occasions, multiple comparisons of the mean values were carried out. For both MVC parameters, it was found that means at the two later examinations did not differ with statistical significance (FLEXION: $F(1,181) = 0.5$, $P > 0.5$; EXTENSION: $F(1,181) = 0.2$, $P > 0.5$), while the mean at the initial examination was statistically significantly smaller (FLEXION: $F(1,182) = 20.0$, $P < 0.0001$; EXTENSION: $F(1,182) = 17.5$, $P < 0.0001$).

Prognostic Value of the Separate Measurement

Anthropometric Measurements. Table 5 shows that the anthropometric measurements were of no prognostic value either for the first-time experience or for the recurrence of LBT in the follow-up year. On the other hand, a comparison of those who previously had LBT (LBT-Y) with those who had never had LBT prior to the initial examination (LBT-N) shows that the LBT-Y men were taller, heavier, and had a greater epicondylar breadth than the men who had never experienced LBT.

Unequal Leg Length. Among 922 of the participants, the right leg was shorter than the left in 17.2%, while the opposite was the case in 25.3%. This side difference is statistically signif-

Table 4. Reproducibility of Maximal Voluntary Contraction at Forward Flexion (FLEXION) and Backward Extension (EXTENSION) of the Trunk (in N) from the Initial Examination to a One-Month and/or a Six-Month Follow-Up Examination. Two-Way Unbalanced Analyses of Variance was Carried Out[74]

	Examination								
	Initial		One-month follow-up		Six-month follow-up				
	n	Mean	n	Mean	n	Mean	Intraperson SD	Analyses of variance	P
FLEXION*	128	575	70	585	118	597	60	F(2,181) = 10.3	<0.001
EXTENSION†	128	756	69	768	119	785	76	F(2,181) = 8.8	<0.001

*50 had all three measurements, 15 the initial and the one-month follow-up, 63 the initial and the six-month follow-up, five the one-month and the six-month follow-up.

†50 had all three measurements, 14 the initial and the one-month follow-up, 64 the initial and the six-month follow-up, five the one-month and the six-month follow-up.

icant ($\chi^2 = 7.02$, df = 1, $P = 0.0081$). The leg length difference was 0.5 cm in 32.1% of the cases, 1.0 cm in 51.5%, 1.5 cm in 12.5%, and 2.0 cm in 2.8% while four participants (1%) exhibited differences greater than 2.0, ie, 2.5, 3.0 (leg fracture), 3.5, and 5.0 cm (poliomyelitis sequelae). In all, 28.9% (ie, 29.8% of the men and 27.9% of the women) had leg length discrepancies equal to or greater than one centimeter.

The leg length discrepancy showed no predictive power of significance for first-time occurrence of LBT in the follow-up year (F-LBT against N-LBT) or for recurrence or persistence of LBT (R-LBT against P-LBT), but when tested in relation to whether the subject ever had LBT prior to the initial examination (LBT-Y as opposed to LBT-N), the LBT-Y group was found to contain significantly more participants with unequal leg length than the LBT-N group ($\chi^2 = 9.16$, df = 1, $P = 0.0025$). Of those with LBT, 46% (264/569) had unequal leg length. This figure was of the same magnitude in all eight sex/age groups. Neither the magnitude of the inequality nor whether the right or left side was shortest was found to give any additional information regarding LBT.

Length of Hamstring Muscles. In all age groups, the women had more elastic hamstring muscles than the men bilaterally and for both tests (HAMSTR-I and HAMSTR-II) (Mann-Whitney tests, $P \leq 0.0001$). On the other hand, no significant age trends were observed (Kruskal-Wallis tests, $P > 0.24$, except for HAMSTR-I, left side, women: $P = 0.030$, the 40-year-olds being most elastic and the 30-year-olds least elastic).

The HAMSTR-II was of some predictive value for recurrence of LBT in women, in that those with tighter hamstrings were more

Table 5. Anthropometric Measurements (cf, Table 1 and text) in Relation to Experience of Low-Back Trouble (cf, Table 2). Prospective: F-LBT vs. N-LBT, and R-LBT vs. P-LBT; retrospective: LBT-Y vs. LBT-N

	Men				Women			
	F-LBT (n = 28)		N-LBT (n = 138)		F-LBT (n = 30)		N-LBT (n = 155)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
HEIGHT (cm)	175.0	8.3	174.2	6.9	162.5	6.8	162.7	6.0
WEIGHT (kg)	77.3	10.4	74.9	9.0	59.8	11.1	62.8	12.3
EPICON (mm)	98.5	4.3	97.7	4.0	89.8	4.8	91.4*	5.2
LEGLENGTH (cm)	90.2	5.9	90.1	4.9	83.4	5.1	83.8	4.4
UPBODY (cm)	84.8	3.9	84.1	3.4	79.0	3.6	78.9	3.1
ROHRINDEX	1.44	0.17	1.42	0.19	1.39	0.23	1.46	0.26
	R-LBT (n = 170)		P-LBT (n = 106)		R-LBT (n = 185)		P-LBT (n = 108)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
HEIGHT (cm)	175.9	7.0	175.8	6.9	162.3	5.9	163.5	6.4
WEIGHT (kg)	77.8	12.9	77.8	10.6	63.4	10.3	64.2	10.8
EPICON (mm)	98.7†	4.9	99.0	4.4	91.3‡	4.9	90.9	4.8
LEGLENGTH (cm)	90.9†	4.9	91.1	4.7	83.4§	4.5	84.4	4.5
UPBODY (cm)	85.0†	3.5	84.7	3.7	78.9§	3.5	79.1	3.5
ROHRINDEX	1.43	0.22	1.43	0.18	1.49	0.26	1.47	0.25
	LBT-Y (n = 281)		LBT-N (n = 168)		LBT-Y (n = 294)		LBT-N (n = 185)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
HEIGHT (cm)	175.8	6.9¶	174.3	7.2	162.7	6.1	162.7	6.1
WEIGHT (kg)	77.8	12.0¶	75.2	9.3	63.6	10.5	62.3	12.2
EPICON (mm)	98.8**	4.7¶	97.8	4.0	91.1††	4.9	91.1‡‡	5.2
LEGLENGTH (cm)	90.9**	4.8	90.1	5.0	83.8§§	4.5	83.7	4.5
UPBODY (cm)	84.9**	3.5	84.2	3.5	79.0§§	3.5	78.9	3.2
ROHRINDEX	1.43	0.20	1.43	0.19	1.48	0.25	1.45	0.26

*n = 154, †n = 168, ‡n = 182, §n = 183, ¶P < 0.05, **n = 279, ††n = 291, ‡‡n = 184, §§n = 292.

Table 6. Length of Hamstring Muscles, Measured in Degrees on Both Sides Using Two Different Methods, in Relation to First-Time Experience and Recurrence or Persistence of Low-Back Trouble in the Follow-Up Year (cf, Table 2). Tested by the Mann-Whitney Rank Sum Test Corrected for Ties

	F-LBT		N-LBT		R-LBT		P-LBT	
	n	*Mean*	*n*	*Mean*	*n*	*Mean*	*n*	*Mean*
HAMSTR-I (right)								
Men	28	73.8	138	75.0	157	73.3	106	72.8
Women	30	77.7	154	78.2	177	77.5	106	78.4
HAMSTR-I (left)								
Men	28	73.6	138	75.5	160	73.8	106	73.2
Women	30	78.2	155	78.1	174	78.0	105	78.7
HAMSTRI-II (right)								
Men	28	19.6	137	18.8	159	21.0	104	19.6
Women	30	13.2	152	11.6	174	12.6*	103	9.9*
HAMSTR-II (left)								
Men	28	20.2	137	19.6	160	21.6	104	20.1
Women	30	14.0	152	11.7	172	13.1†	102	10.5†

*P = 0.030, †P = 0.027. All other *P* values ≥0.15.

liable to get LBT (Table 6). Otherwise no significant indications appeared.

Seventeen participants (10 men and 7 women) in whom one or more of the four tests resulted in pain in the lower back and/or radiating pain to the leg(s) were not included in the respective analyses.

Flexibility/Elasticity. The modified Schober test (SCHOBER) gave higher values for men than women (*t* test, $P<0.0005$) and the values decreased with age in both sexes (analyses of variance, men: $F(3,443) = 25.4$, $P<0.00005$; women: $F(3,472) = 2.44$, $P = 0.064$). The fingertip–floor distance (FINGFLOOR) was larger for men than women (Mann-Whitney rank sum test, $P<0.00005$) and increased with age in men (Kruskal-Wallis test, $P = 0.041$), while among the women the 30-year-olds showed a higher mean rank in the test than the 40-year-olds, but an equal one to the 50-year-olds and a lower rank than the 60-year-olds (Kruskal-Wallis test, $P = 0.002$).

Table 7 shows that the Schober test was of some prognostic value among men regarding first-time experience of LBT, in that those with the more mobile lumbar spines were more liable to get LBT. The women, however, showed the opposite trend.

A large fingertip–floor distance proved to be of some predictive value among women for recurrence or persistence of LBT. The same pattern was apparent among the men though not with statistical significance.

Trunk Muscle Strength. As expected, the strength (SITUP, LEGLOW, FLEXION, and EXTENSION) was larger in men and decreased with age ($P<0.00005$, except for LEGLOW, where no age trend was observed). The flexion/extension ratio (FLEXEXT) presented no particular sex or age differences.

The trunk muscles tended to be weaker among those who experienced recurrence of LBT in the follow-up year compared with those without recurrence (Tables 8 and 9). For first-time LBT, no clear trend was observed.

Isometric Muscle Endurance. About 76% of both the men and women completed this test, although it is probably fair to assume that the shortest endurance times were among persons with no real motivation to carry the test through until fatigue. Of those who did not complete the test, 35% of the men and 25% of the women gave pain in the back as the reason. Others discontinued the test because of discomfort in particular in the legs or abdomen. These complaints are mainly to be attributed to the test method. The endurance time was longer for the women than the men in all age groups (Mann-Whitney rank sum tests, $P \leq 0.0012$) and decreased with age in both sexes (Kruskal-Wallis tests, men: $P = 0.035$; women: $P = 0.015$).

Table 7. Spinal Flexibility Evaluated Using Two Different Methods, in Relation to First Time Experience and Recurrence or Persistence of Low-Back Trouble in the Follow-Up Year (cf, Table 2)

	Men		Women		Men		Women	
	F-LBT (n = 28)	N-LBT (n = 138)	F-LBT (n = 29)	N-LBT (n = 155)	R-LBT (n = 168)	P-LBT (n = 106)	R-LBT (n = 183)	P-LBT (n = 108)
SCHOBER								
Mean (mm)	71.9	67.2	62.5	65.3	66.6	68.6	63.3	64.4
SD (mm)	9.2	8.9	10.2	9.5	10.4	9.7	11.5	9.4
Range (mm)	55-94	41-90	45-84	36-90	10-86	43-92	32-103	39-94
P (*t* test)	0.012		0.15		0.11		0.43	
FINGFLOOR								
Mean (cm)	4.1	3.6	3.1	1.6	6.1*	4.2	3.3	1.1
Pct. >0 cm	32	33	24	13	41	29	25	10
Maximum (cm)	19	33	34	26	55	29	39	25
P (Mann-Whitney rank sum test)	0.83		0.12		0.060		0.002	

*n = 167.

Table 8. Abdominal Muscle Strength Evaluated by Means of Two Different Methods, in Relation to First Time Experience and Recurrence or Persistence of Low-Back Trouble in the Follow-Up Year (cf, Table 2)

	Men		Women		Men		Women	
	F-LBT	N-LBT	F-LBT	N-LBT	R-LBT	P-LBT	R-LBT	P-LBT
SITUP								
n	27	138	29	153	156	106	173	106
% grade 1	93	79	52	52	78	88	35	44
% grade 2	7	17	28	29	15	10	30	29
% grade 3	0	2	10	10	3	1	16	13
% grade 4	0	1	10	9	3	1	20	13
P	0.093		0.90		0.041		0.065	
LEGLOW								
n	26	138	27	153	149	105	167	103
% grade 1	12	10	0	4	11	13	0	3
% grade 2	35	40	15	16	37	46	19	12
% grade 3	39	37	22	21	28	27	20	23
% grade 4	8	11	30	32	21	11	31	31
% grade 5	8	1	26	24	3	4	28	27
% grade 6	0	1	7	5	0	0	3	4
P	0.73		0.51		0.075		0.84	

Tested by the Mann-Whitney rank sum test corrected for ties.

Table 10 shows that the isometric back muscle endurance was of significance for prediction of first-time occurrence of LBT among men in the follow-up year. However, the women showed an insignificant trend in the opposite direction.

Correlation of Measurements. Table 11 gives the Pearson correlation coefficients for the interrelation of all the physical measurements used in the discriminant analyses. Of these correlations, some interrelationships should be pointed out. The length measurements (HEIGHT, LEGLENGTH, UPBODY) were found to be correlated to the maximal isometric trunk muscle strength measurements (FLEXION and EXTENSION) and to SITUP, while no distinct correlation was found to LEGLOW or ENDURANCE. On the other hand, when considering the interactions with WEIGHT and ROHRINDEX, the last two muscle tests were particularly significantly correlated. WEIGHT alone was also significantly related with the maximal isometric muscle tests. EPICON was also, in particular, correlated to these MVC tests.

All the muscle tests (SITUP, LEGLOW, FLEXION, EXTENSION and ENDURANCE) were, with one exception (LEGLOW vs. ENDURANCE), found to be significantly correlated with each other.

Regarding the flexibility/elasticity measurements (HAMSTR-I, HAMSTR-II, FINGFLOOR and SCHOBER) it is noteworthy that the fingertip–floor distance in both sexes was significantly correlated to the length of the hamstrings, while the modified Schober test did not show a uniform relationship with hamstring tightness. Nevertheless, FINGFLOOR and SCHOBER showed a significant correlation.

Sex differences in the correlations in Table 11 are particularly noted for the SCHOBER test in both relation to anthropometric measurements and isometric trunk muscle tests.

The results of the above analyses of the prognostic importance of the separate measurements, which are summarized in Table 12, must be viewed in light of the correlations just mentioned. The purpose of the discriminant analyses that follow is, i.a., to pick out the most important predictor(s) from each cluster of mutually correlated parameters and combine them with independent pieces of prognostic information.

Discriminant Analyses

Several of the parameters used in the discriminant analyses are discrete and cannot be assumed to be distributed normally. In practice, the stepwise discriminant analysis technique used[59,65] has been demonstrated[85] to be very robust even in case of such deviations from the normal distribution; therefore, special precautions have not been taken with regard to these parameters.

In the analyses the measurements for the length of hamstring muscles (methods I & II) on the right and the left side are added

Table 9. Maximal Isometric Strength (in N) at Forward Flexion and Backward Extension of the Trunk and the Ratio of These Two Measurements, in Relation to First-Time Experience and Recurrence or Persistence of Low-Back Trouble in the Follow-Up Year (cf, Table 2)

	F-LBT			N-LBT			R-LBT			P-LBT		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
FLEXION												
Men	26	706	160	133	690	164	145	692	167	101	701	155
Women	27	331	101	147	358	100	161	315*	97	98	357*	103
EXTENSION												
Men	27	936	166	133	895	190	143	886	184	100	919	200
Women	26	434	144	147	461	129	155	419†	128	98	470†	145
FLEXEXT												
Men	26	76.5%	13.9%	133	77.6%	11.9%	138	78.7%	14.3%	100	77.9%	13.3%
Women	26	76.6%	12.8%	147	79.0%	14.6%	152	77.4%	16.4%	96	78.2%	15.7%

*t = −3.28, df = 257, P = 0.001; †t = −2.95, df = 251; P = 0.003. All other P values above 0.18.

Table 10. Isometric Back Muscle Endurance (in Seconds) in Relation to First Time Experience and Recurrence or Persistence of Low-Back Trouble in the Follow-Up Year (cf. Table 2)

	Men		Women		Men		Women	
ENDURANCE	F-LBT	N-LBT	F-LBT	N-LBT	R-LBT	P-LBT	R-LBT	P-LBT
n	24	119	23	129	110	85	125	85
Mean	176	198	210	197	163	175	177	191
Median	175.5	203	240	240	160.5	180	185	229
Minimum	110	55	76	1	29	19	11	5
Pct. 240s	25%	44%	61%	52%	20%	26%	38%	46%
P	0.029		0.34		0.13		0.11	

Tested by the Mann-Whitney rank sum test corrected for ties.

and divided by two for each of the two methods separately—which is justified in view of the high correlation coefficients ($r \geq 0.93$, cf, Table 11).

First-Time Experience of LBT

In the follow-up year, 58 participants experienced LBT for the first time, while 293 still had never experienced LBT by the end of the follow-up year; all parameters listed in Table 11 were satisfactorily known for 42 (22 men and 20 women) of the former and 238 (116 men and 122 women) of the latter participants, and these were used in the analyses.

It has been demonstrated previously[14,16] that age influences the LBT frequencies differently for men and women, ie, a sex–age interaction is to be assumed. Likewise the sex can be suspected to interact with several of the other parameters. Therefore, analyses were performed separately for men and women.

For *men* it was found that age, modified Schober test, and isometric back muscle endurance discriminate between those with first-time experience of LBT and those who had never had LBT ($F(3,139) = 6.34$, $P < 0.001$). Thus those who had experienced LBT had a larger Schober value (cf, Table 7) and a shorter endurance time (cf, Table 10).

When including all men (24 + 119) for whom ENDURANCE and SCHOBER were known, the estimated discriminant function is:

$L = 0.012 \times ENDURANCE - 0.080 \times SCHOBER + K$, where K depends on age (30 years: 3.014; 40 years: 4.017; 50 years: 3.465; 60 years: 2.362). When $L < O$ the participant is classified as belonging to those predicted to experience LBT for the first time in the follow-up year, while $L > O$ means that the participant is classified with those who never suffered LBT.

Altogether, this discriminant function misclassified 37% of the men. Of the 24 men who had LBT for the first time in the follow-up year, three (12.5%) were classified incorrectly, and among the 119 men without LBT in the follow-up year, 50 (42%) were misclassified.

For *women* the analysis showed age, MVC at backward extension of the trunk and endurance time to discriminate between the two groups ($F(3,139) = 5.01$, $P = 0.002$). Thus those with first-time experience of LBT were on the average four years younger, had less MVC at backward pull, and a longer endurance time than those without LBT in the follow-up year. In contrast to the other discriminant analyses, none of the one-dimensional (marginal) t tests had P values below 0.05. Further, the few women omitted from this discriminant analysis because of lack of one or more parameters meant an increased difference of 31 N for MVC at backward extension and 10 seconds for the endurance time between the LBT-F and the LBT-N group as compared with the results in Tables 9 and 10.

Nevertheless, when including all women (21 + 122) for whom the measurements in question are known, the estimated discriminant function is:

$L = 0.050 \times AGE + 0.0070 \times EXTENSION - 0.012 \times ENDURANCE - 2.783$. The sign of L discriminates between the two groups as described above for men. Here 33% of all women were misclassified. Among the 21 women who had their first time experience of LBT in the follow-up year, nine (43%) were classified wrongly. Of the 122 women who did not get LBT in the follow-up year, 38 (31%) were misclassified.

Recurrence or Persistence of LBT

For the *men*, all parameters used in the analysis (those listed in Table 11 plus LBTLAST) were known for 92 of those who had recurrence or persistence of LBT in the follow-up year and for 76 of those without recurrence.

The number of weeks since last experience of LBT (LBTLAST) was the only parameter found to have significant association with recurrence or persistence of LBT in the follow-up year ($P < 0.001$). Thus men with recurrence had on the average experienced LBT 51 weeks prior to the initial examination, while those without LBT in the follow-up year had last experienced it 171 weeks before the initial examination.

When taking all men with LBTLAST known (166 + 102) and classifying them in accordance with the number of weeks since the last episode of LBT by using the best possible intersection point of 31 weeks 30.2% were misclassified. Of those with LBT in the follow-up year, 29 (17%) were categorized incorrectly, and among those with no LBT in the follow-up year, 52 (51%) were misclassified.

Considering the *women*, all parameters for the discriminant analysis were known for 111 of those who experienced recurrence or persistence of LBT in the follow-up year and 79 who had had LBT previously but not in the follow-up year.

The analysis showed MVC at forward flexion of the trunk (cf, Table 9) together with the number of weeks since last episode of LBT to discriminate between the two groups considered ($P < 0.001$). Those with recurrence had had their last episode on the average 29 weeks prior to the initial examination, while for those without recurrence in the follow-up year the average was 121 weeks.

The estimated discriminant function is:

$L = 0.0061 \times FLEXION + 0.0042 \times LBTLAST - 2.2633$, when based upon all those 159 women with recurrence and those 96 women without recurrence for whom at least the two discriminating parameters were known. When $L < O$ the woman was classified as belonging to the group with recurrence or persistence of LBT in the follow-up year, while $L > O$ meant that the woman was classified as having no recurrence of LBT.

Table 11. Correlation of the parameters in the discriminant analyses illustrated by Pearson correlation coefficients. In upper right triangle of the table the correlation coefficients for men (n=395–449; for ENDURANCE n=321–341) are given and in the lower left triangle the correlation coefficients for women (n=414–479; and for ENDURANCE n=340–363). Abbreviations as in Table 1

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
1 HEIGHT		.89‡	.76‡	.47‡	−.38‡	.59‡	−.00	−.10*	−.10*	.15†	.13†	.05	.13†	−.26‡	−.10*	.35‡	.22‡	.19‡	.08	−.27‡
2 LEGLENGTH	.84‡		.38‡	.44‡	−.32‡	.52‡	.03	−.13†	−.12†	.17‡	.14†	.12†	.04	−.21‡	−.09*	.29‡	.13†	.23‡	.07	−.14†
3 UPBODY	.69‡	.18‡		.33‡	−.32‡	.46‡	−.04	−.03	−.02	.07	.05	−.08	.21‡	−.23‡	−.06	.30‡	.25‡	.07	.06	−.36‡
4 WEIGHT	.33‡	.41‡	.06		.63‡	.67‡	−.02	−.02	.02	−.00	−.07	.03	.04	.06	−.32‡	.37‡	.44‡	−.04	−.16†	−.01
5 ROHRINDEX	−.31‡	−.13†	−.38‡	.79‡		.19‡	−.02	.07	.11*	−.13†	−.18‡	−.01	−.08*	.31‡	−.24‡	.08	.28‡	−.21‡	−.23‡	.23‡
6 EPICON	.30‡	.34‡	.08*	.69‡	.50‡		.01	.01	.04	−.01	−.05	−.03	.08*	−.06	−.14†	.35‡	.29‡	.12†	.03	−.05
7 LEGINEQ	−.02	.03	−.07	−.02	−.01	−.01		.02	.03	−.00	−.03	.01	−.10*	.04	.01	−.00	−.06	.09*	.02	.13†
8 HAMSTR-I (right)	−.07	−.06	−.05	−.01	.04	−.00	−.03		.96‡	−.79‡	−.75‡	−.65‡	.05	−.08	−.11*	.13†	.14†	−.05	.22‡	.02
9 HAMSTR-I (left)	−.06	−.06	−.02	−.01	.02	−.00	−.03	.93‡		−.78‡	−.79‡	−.66‡	.07	−.03	−.11*	.12†	.16†	−.08	.19‡	.02
10 HAMSTR-II (right)	.06	.04	.06	−.06	−.10*	−.03	−.01	−.68‡	−.64‡		.93‡	.55‡	−.09*	.08*	.12†	−.14†	−.16†	.03	−.21‡	−.04
11 HAMSTR-II (left)	.03	.02	.03	−.07	−.09*	−.02	.03	−.66‡	−.68‡	.93‡		.55‡	−.10*	.08	.14†	−.15†	−.18‡	.03	−.18†	−.04
12 FINGFLOOR	.09*	.14†	−.02	.09*	.03	.08*	−.01	−.70‡	−.73‡	.56‡	.60‡		−.35‡	.16‡	.05	−.15†	−.19‡	.07	−.20‡	.12†
13 SCHOBER	−.10*	−.09*	−.06	.07	.15†	.10*	−.05	.02	.02	−.00	−.01	−.20‡		−.31‡	.03	.19‡	.25‡	−.05	.17†	−.38‡
14 SITUP	−.21‡	−.13†	−.21‡	.12†	.26‡	.06	.12†	−.10*	−.09*	.15†	.15†	.19‡	−.22‡		.13†	−.34‡	−.23‡	−.13†	−.26‡	.29‡
15 LEGLOW	.00	.08*	−.10*	−.21‡	−.22‡	−.09*	.10*	.00	.00	.07	.06	−.03	−.10*	.33‡		−.22‡	−.20‡	−.07	.08	.08
16 FLEXION	.29‡	.24‡	.20‡	.25‡	.06	.15†	.04	.10*	.07	−.16†	−.17‡	−.12†	.04	−.39‡	−.27‡		.71‡	.43‡	.23‡	−.36‡
17 EXTENSION	.27‡	.19‡	.25‡	.19‡	.02	.14†	−.00	.09*	.05	−.13†	−.15†	−.13†	−.01	−.26‡	−.23‡	.81‡		−.31‡	.21‡	−.32‡
18 FLEXEXT	.03	.11*	−.10*	.12†	.09*	.03	.04	.03	.04	−.04	−.02	.04	.08*	−.11*	−.07	.22‡	−.36‡		−.11*	.07
19 ENDURANCE	.05	−.01	.11*	−.29‡	−.31‡	−.19‡	−.04	.12†	.10*	−.07	−.08	−.15†	−.04	−.31‡	.07	.18‡	.25‡	.05		−.17†
20 AGE	−.26‡	−.11†	−.33‡	.16‡	.34‡	.17‡	.01	.04	.03	−.02	.02	.11†	−.11†	.45‡	.01	−.29‡	−.30‡	−.05	−.20‡	

*P < 0.05, †P < 0.01, ‡P < 0.001.

Table 12. Summary of Risk Indicators for First-Time Experience (F-LBT) and for Recurrence or Persistence (R-LBT) of Low-Back Trouble in the Follow-Up Year, When the Physical Measurements were Tested Separately ($P<0.05$)

Parameter	*Indicative of F-LBT*	*Indicative of R-LBT*
HAMSTR-II		if tight(♀)*
SCHOBER	if flexible (♂)†	
FINGFLOOR		if large (♀)*
SITUP		if weak (♂)*
FLEXION		if weak (♀)*
EXTENSION		if weak (♀)*
ENDURANCE	if low(♂)†	

*Same trend in the other sex.
†Opposite trend in the other sex.

This discriminant function categorized 38% of the women incorrectly. Among those with LBT in the follow-up year, 54 (34%) were misclassified, while the figure for those without LBT was 43 (45%).

The association of the physical measurements to the time elapsed since the last LBT-episode is illustrated in Table 13.

DISCUSSION

The Delimitation of LBT

As previously emphasized,[16] LBT is a subjective complaint and thus impossible to validate objectively.[93] In most cases the exact underlying cause remains uncertain even after full investigation, which means that one has to adopt a pragmatic approach.[94] Furthermore, in using the survey method much of the information is historic, and the threshold of recall varies with the recency of the episode and the method of presenting the question(s) about LBT.[18] Therefore the delimitation of LBT in this study is based solely upon the question mentioned above. Regarding the reproducibility of the auto-anamnestic information about LBT, it was found for the present study that the question as to whether the subject ever had LBT was answered consistently by 84% at an interval of about six months.[18]

The Physical Measurements

The leg length inequality was evaluated by using a spirit level resting on the iliac crests. This procedure might have introduced some uncertainty, but according to a radiological study[10] the iliac crest was low on the side of shortness in 88% of 550 cases of anisomelia. Another possible cause of uncertainty is that the measurement may be difficult to perform in obese persons.[23] However, radiation risks[45] would render radiological determination of the leg length discrepancy unethical in a study such as this. The finding of about 30% with leg length inequality of one centimeter or more is in accordance with Hult.[37] But these high frequencies are claimed to be a result of clinical over-estimation, due to pelvic asymmetry and/or torsion.[26] There seems to be wide disagreement over whether the right or the left leg is most often the short one;[10,11,26,37] as this disagreement is also present in radiological studies, it seems difficult to explain.

The coefficients of variation given in Table 3 show the measurements listed to be reproduced satisfactorily. For the LEGLENGTH, this is in agreement with previous reports when it is not measured with an accuracy of less than one centimeter.[11,37,58]

The modified Schober test (SCHOBER) showed a coefficient of variation (4.8%, Table 3) of the same magnitude as found by Adrichem and Korst[2] for a very similar test, and the same degree of reproducibility has also been demonstrated by others,[46,53] though Reynolds[68] found a coefficient of variation of 11.7%. The modified Schober test was chosen because Macrae and Wright[49] have shown that the distraction between the two skin marks is correlated closely ($r = 0.97$) with the anterior flexion of the lumbar spine measured radiologically. In addition, they found the test to be independent of hip movements. This is supported by the low degree of correlation with the length of the hamstring muscles found in the present study (Table 11). Furthermore, the American Academy of Orthopaedic Surgeons has concluded that the tape-measure method is the most accurate one for estimating the true spine motion during flexion.[4] This measurement for lumbar spinal mobility also was chosen because previous studies had shown that anteflexion is the spinal motion most often affected in spinal trouble.[13,50,75,86,90] Finally the test was found to be easy in practice. The significant increase observed in the test values from the initial examination to the six-month follow-up may be explained as a "learning" effect. Among the subjects used in the calculation of the coefficient of variation (Table 3), four increased and two decreased the test values from the first to the second measurement. The progressive decrease in lumbar spinal flexibility (SCHOBER) with advancing age is supported in the literature.[30,37,49,54,77,92] Likewise, it

Table 13. The Association Between the Listed Physical Measurements and the Interval Between the Last Episode of Low-Back Trouble (LBT) and the Initial Examination. Also Given is the Risk of Experiencing LBT in the Follow-Up Year

	Men						*Women*					
	Interval to the last LBT-episode				*No LBT previously*		*Interval to the last LBT-episode*				*No LBT previously*	
	<1 week		*≥1 week*				*<1 week*		*≥1 week*			
	n	*Mean*	*n*	*Mean*	*n*	*Mean*	*n*	*Mean*	*n*	*Mean*	*n*	*Mean*
HAMSTR-I, right (degrees)	45	72.4	216	73.2	168	74.8	63	77.2	217	78.1	184	78.1
HAMSTR-I, left (degrees)	44	73.0	220	73.6	168	75.2	61	78.0	215	78.4	185	78.1
HAMSTR-II, right (degrees)	46	22.1	216	20.1	167	19.0	63	14.4	211	10.8	182	11.8
HAMSTR-II, left (degrees)	45	23.2	218	20.5	167	19.8	62	14.8	209	11.4	182	12.1
FINGFLOOR (cm)	51	9.6	220	4.5	168	3.6	69	5.3	219	1.6	184	1.9
SCHOBER (mm)	51	64.3	221	68.0	168	68.0	69	62.2	219	64.2	184	64.8
SITUP (grades)	42	1.6	218	1.2	167	1.2	63	2.5	213	2.0	182	1.8
LEGLOW (grades)	37	2.9	214	2.5	166	2.6	54	3.8	213	3.8	180	3.7
FLEXION (N)	34	650	210	699	161	692	53	302	203	335	174	354
EXTENSION (N)	31	847	210	906	162	901	48	418	201	441	173	457
ENDURANCE (seconds)	21	164	169	169	144	195	34	151	173	190	152	199
Risk of experiencing LBT in the follow-up year	49	77%	219	56%	166	17%	72	75%	218	55%	185	16%

has been shown previously that men are more flexible than women.[49] The importance of the differences observed between men and women for the correlations of the modified Schober test to anthropometric measurements and isometric muscle tests is not clear.

Both the fingertip-floor distance and the length of the hamstring muscles (method II) were shown to be reproducible even at an interval of about six months. Likewise, Sweetman et al[77] and Fisk[25] have shown the straight leg raising test, and a modification of it, to be satisfactorily reproducible. The significant correlation observed between elasticity of the hamstrings and the fingertip-floor distance is not unexpected as the latter test, in part, depends on the hamstring tightness. The fact that the fingertip-floor distance and the modified Schober test also are correlated significantly, while hamstring tightness and Schober are uncorrelated, means that the fingertip-floor distance is a combined evaluation of at least hamstring tightness and spinal flexibility, for which reason it may be a misleading measurement.[2,55]

Regarding the maximal isometric muscle tests (FLEXION and EXTENSION) the coefficients of variation (Table 3) are like those reported by Chaffin et al[21] for isometric strength test is controlled laboratory studies. Acceptable, but sometimes not quite as good, reproducibility has been demonstrated by others.[8,9,21,51,79,81] Pedersen and Staffeldt[63] found the test used here for isometric back muscle strength to be the most reliable among four different back muscle strength tests. The subject's motivation is of major importance for the result of these tests. This motivational factor and/or enhanced skill may be the reason for the increased strength recorded in the participants at the follow-up examinations (Table 4), which is in accordance with earlier experience.[81] In this connection, it should be noted that no tendency was found towards higher values of MVC at the second test compared with the first one among the subjects used for the calculations of the coefficients of variation in Table 3.

Regarding the associations between the anthropometric measurements and the muscle tests, Tornvall[81] has found a significant correlation between maximal isometric trunk muscle strength and body weight and femoral epicondylar breadth, but not body height, while Asmussen and Heebøll-Nielsen[6] showed a clear relationship to height. In the present material, all three of these anthropometric measurements were correlated significantly with the maximal isometric trunk muscle strength tests. The finding that both the dynamic (SITUP and LEGLOW) and the static (FLEXION and EXTENSION) muscle strength tests were better performed by men than women and were performed less well with increasing age is in agreement with the literature.[29,47,51,61,62,64,75,84] Also in accordance with previous experiences,[3,6,29,51,79,80,88] is the fact that backward extension of the trunk showed higher test values than forward flexion (FLEXEXT < 1) and the observation that no difference exists between the two sexes in this respect.[6,51,83] No information regarding sex or age relations for isometric back muscle endurance (viz, ENDURANCE) seems to be available from other studies. The fact that in the present study women showed better test results than men might be explained partly by anthropometric differences, as it has been shown previously that the women with the longest endurance times were lighter and had smaller femoral epicondylar width than the others.[17] A problem with the method employed for measuring the isometric back muscle endurance is that a high degree of motivation is necessary to carry the test through, which might be the reason for some of the many failures. In the present test, the participants were informed beforehand of the upper limit of 240 seconds. Most participants who reached this limit claimed they would not be able to continue further, while others might have continued beyond the 240 second limit, which is supported in another study[82] where the same test gave endurance times up to 320 seconds.

Prognostic Value

The anthropometric measurements did not show any prognostic value for LBT in the follow-up year in either the individual or the discriminant analyses. However, retrospectively, it is seen that taller men more often complained of LBT, which accords with some previous studies,[27,36,41,48,78] but not with others.[22,24,31,64,69,70,89,90] Likewise, body weight was correlated positively with LBT among men, which is also supported in some studies[36,40,52,64] although this association seems even more open to dispute than the relation to body height,[22,24,27,31,41,69-71,89,90] and in the present study the associations were observed for men only. That the body type expressed as Rohrer's index was unrelated to LBT is in agreement with other Scandinavian studies.[37,38,89] The positive relationship observed, though among men only, between femoral epicondylar width and LBT has not been reported previously.[31,91]

Likewise, unequal leg length gave no indication of LBT in the follow-up year, although retrospectively, significantly more participants with an experience of LBT had leg length discrepancy than those without LBT. This accords with some studies,[23,57,72,76] but not with others.[26,34,37,38,69,70,71]

Considering the flexibility/elasticity measurements and the muscle tests, the results of the discriminant analyses were largely in correspondence with the results of the analyses on the separate measurements (Table 12).

Regarding the value of the physical measurements as indicators of first-time experience of LBT, no information has been found in the literature. For men, those with greatest mobility in their lumbar spine and the shortest endurance times were shown to be most liable to experience LBT for the first time in the follow-up year. This observation may support the hypothesis that hypermobile men more easily will contract LBT, in accordance with the suggestion that "the joint laxity is a primary event in the pathogenesis of spondylolisthesis . . ."[19] or that "the score for musculoskeletal symptoms always is positively related to the mobility score."[12] Furthermore, Howes and Isdale[35] suggested central and peripheral hypermobility as an important differential diagnosis of backache, though only in women, while the present material shows this for men, with the women having the opposite trend. That there may be a true sex difference might be supported in view of the previously mentioned differences between men and women in relation to the modified Schober test, although these are not explainable for the time being.

That men with high isometric endurance of the back muscles should be protected to some extent against LBT would seem to be explained by the fact that the back muscles maintain the erect posture of the spine throughout the day. The women showed the opposite tendency in the discriminant analysis, but as mentioned, the explanation might be that the few women omitted from this analysis made a large difference in this respect. The same analytical problem was true when considering the importance of isometric strength at backward extension of the trunk observed in the same discriminant analysis for women.

Whatever relation might exist between the physical measurements and the recurrence or persistence of LBT in the follow-up year, it was found to be represented nearly fully by the association to the number of weeks since last experience of LBT. Thus MVC at forward flexion in women was the only parameter that showed statistical significance in the discriminant analysis beside LBT-LAST. But the trend that participants with weaker trunk muscles

more often experienced recurrence in the follow-up year compared with those with stronger trunk muscles was rather uniform in both sexes (cf, Tables 8 and 9). This might well be because the participants in the LBT-R group were to a greater extent persons with either more recent or more chronic LBT; thus the weakness might be a "residual finding,"[70,92] recalling that participants who had pain at the test have been excluded from the analyses. The literature strongly indicates that back trouble reduces trunk muscle strength,[1,3,13,29,40,44,51,52,56,60,61,62,71,75,79] and in one of the few prospective studies, Troup et al[84] found reduced dynamic strength of trunk flexor muscles to be a consistent predictor for recurrence or persistence of back pain. In addition, two other longitudinal studies[20,43] have demonstrated that isometric trunk muscle strength tests might be of value in selection of workers so as to reduce back injuries in strenuous jobs, although it is emphasized[43] that the ideal solution is "redesign of stressful jobs so that they will accommodate the physical capabilities of the work force."

The intra-individual trunk strength ratio (FLEXEXT) was of no prognostic value for future occurrence of LBT (cf, Table 9), which is in accordance with the finding that this ratio is the same in LBT patients and controls.[3,75] However, McNeill et al[51] found the patients to have less strength in trunk extension than in flexion, the relative weakness of the extensors being particularly pronounced for patients with sciatica.

The correlation of flexibility/elasticity measurements with LBTLAST (Table 13) were such that they only could be seen as statistically significant indicators for recurrence or persistence of LBT in the analyses of the separate measurements (Tables 6 and 7), and in women only. This finding of reduced elasticity among those who experienced LBT in the follow-up year might also be a reminiscence of previous or ongoing LBT, and is in agreement with restricted spinal movements being closely associated with back pain.[13,28,34,37,38,44,50,62,70,75,84,88,89,90,92] In his follow-up study of disc herniations, Weber[90] has even concluded that the recovery of a normal mobility of the back is the most reliable sign of normalization of function.

Finally, when reviewing the results of the analyses based on the various physical measurements, the least useful tests in differentiating the groups analyzed were found to be HAMSTR-I for measuring the length of the hamstring muscles and the leg-lowering test (LEGLOW).

CONCLUSION

The principal finding of this investigation is that good isometric endurance of the back muscles seems to prevent first-time experience of LBT in men. Likewise, indications were found that men with a hypermobile back are more liable to contract LBT.

Physical measurements as indicators for recurrence or persistence of LBT are represented primarily by the association to the number of weeks since the last LBT-episode. Thus, residual findings like weak trunk muscles and reduced flexibility/elasticity of the back and hamstrings are more pronounced among those who experience recurrence or ongoing LBT in the follow-up year.

Some of the retrospective observations, including unequal leg length, tallness, and heaviness among men, may be of interest since this study only had a follow-up period of one year. A longer period of follow-up may reveal some additional risk indicators.

When considering the uncertainties of the LBT diagnosis, a fair assumption is that those risk indicators identified in spite of this "noise" will be worth further investigation. Of particular interest would be a test of the effect of back muscle endurance training in the prevention of LBT.

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