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CORRELATIONS BETWEEN JOINT AND SPINAL MOBILITY, SPINAL SAGITTAL CONFIGURATION, SEGMENTAL MOBILITY, SEGMENTAL PAIN, SYMPTOMS AND DISABILITIES IN FEMALE HOMECARE PERSONNEL

Gunnar Lundberg[12] and Björn Gerdle[13]

From the [1]Department of Rehabilitation Medicine, Faculty of Health Sciences, Linköping, the [2]Ergonomicentrum, Nyköping and the [3]Pain and Rehabilitation Centre, University Hospital, Linköping, Sweden

The aim of a study comprising 607 women working as homecare personnel was to investigate general spinal, joint and segmental mobility, different symptoms (pain and strain) and their relation to various aspects of disability. Joint mobility (mainly peripheral) was estimated using the "Beighton" score and spinal posture and mobility were measured by kyphometer. Passive segmental mobility and pain provocation were estimated manually. Pain intensity and strain during work and leisure were estimated using visual analogue scales for defined anatomical regions. Disability was rated using defined items and two indices. The 7-day prevalence of low back pain was 48%. Peripheral joint mobility, spinal sagittal posture and thoracic sagittal mobility showed low correlations with disability. Lumbar sagittal hypomobility was associated with higher disability. Manually estimated segmental mobility and segmental pain provocation of L4-L5 and L5-S1 correlated with disability; hypo- and hypermobility or positive pain provocation tests at these levels showed higher disability than normal mobility and negative pain provocation tests, respectively. Cluster analysis revealed that the combination of positive pain provocation tests and low lumbar sagittal mobility was associated with particularly high disability levels. In conclusion, positive pain provocation tests were clearly associated with high disability levels.

Key words: women, homecare, pain, musculoskeletal, kyphometry, segmental mobility, hypermobility, spine, joint mobility, low back pain.

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Correspondence address: Professor Björn Gerdle, Department of Rehabilitation Medicine, Faculty of Health Science, SE-581 85 Linköping, Sweden. E-mail: Bjorn.Gerdle@rehab.inr.liu.se

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INTRODUCTION

Chronic low back pain is widely considered to be a major health and economic problem (1–3). Statistics obtained world-wide indicate that 60–80% of all adults have experienced or will experience low back pain (4). A small minority (5–10%) will develop chronic low back pain and this subgroup is associated with the major part of the total costs (70–90%) (4, 5). Back pain is a very common reason for consultation in primary care (5, 6). There is considerable agreement that it is important not to restrict the focus solely on symptoms and signs in patients with chronic low back pain or in other patients with chronic pain. In 1980 WHO presented a model of the long-term consequences of disease, which emphasized that other areas than symptoms and signs (i.e. impairments) of a person's life are affected (disabilities and handicap). Waddell and co-workers concluded that correlations between pain, physical impairment and disability are generally low (7). Furthermore, signs have been found to have little relevance for the outcome of the disability level (for instance, incapacity benefit or return to work) (cf. 8–10).

Homecare service is the part of the public health system in Sweden that takes care of the elderly and handicapped individuals, when necessary (11). The working situation of homecare personnel in Sweden contains frequent heavy lifting and forward bending (11). Employees within this sector report a high prevalence of work-related musculoskeletal pain (12) and complaints of this kind are associated with high prevalence of long-term incapacity benefit compared to the situation of child carers, nursery-school teachers and teachers (13).

Signs such as segmental mobility and/or segmental pain provocation tests are part of the clinical practice of manual (orthopaedic) medicine and stated to be important despite a shortage of confirmatory studies, for instance those investigating reproducibility and validity. We recently investigated segmental mobility and pain provocation tests at L4-S1 levels in female homecare personnel. We reported good inter-tester reliability and indications of criterion validity for segmental mobility with respect to spinal mobility (14). Strender et al. also found acceptable inter-tester reliability of segmental mobility of L4-S1 when the testers were physiotherapists but not when the testers were physicians. They suggest that increased standardization of clinical tests is desirable (3).

Commonly used signs, such as mobility tests of the lumbar spine, are often only weakly correlated with disability (cf. 8–10). We asked whether segmental tests of the low back (i.e. segmental mobility and segmental pain provocation tests) would show significant correlations with disability. The main aims of the present study were to investigate to what extent signs of general joint mobility, thoracolumbar spine mobility, segmental spinal mobility and segmental pain provocation tests and

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symptoms (pain and strain during work and leisure in different anatomical regions) correlated with disabilities (common activities of daily living and incapacity benefit) in female homecare personnel.

MATERIALS AND METHODS

Subjects

Subjects taking part in the study had to fulfil the following criteria: employed by the local authority of Nyköping (Sweden) and working at least 50% part time as homecare personnel (permanent appointment or employed long-term (>1 year) without a permanent position). All female employees fulfilling these criteria were invited to participate in the study; 607 (94%) out of 643 subjects participated in this study; 1.3% out of 607 were on parental leave and 1.5% were on incapacity benefit. The subject sample consisted of homecare personnel currently working and not on long-term benefit.

Procedures

The subjects received both written and verbal information about the study, which included the following stages:

1. A questionnaire covering some anthropometric and sociodemographic variables was used. Pain intensity was asked for as an average of pain intensity in the last month for nine anatomical regions separately (neck, shoulder, arm, hand, upper back, lower back, hip, knee and foot) as described by the Nordic Minister Council questionnaire (15). Perceived strain in the same anatomical regions was asked for both in leisure time and at work. Pain intensity, strain and disability scales were 100-mm visual analogue scales (VAS). The anchor points were "no perceived pain = 0, no perceived strain = 0, activity without difficulty = 0" and "maximal strain/pain = 100 or cannot do the activity at all = 100".

The Disability Rating Index (DR-index) was used to assess mainly physical aspects of disability (16). Twelve items are divided into three sections: items 1–4: common basic activities of daily life; items 5–8: more demanding daily physical activities; items 9–12: work-related or more vigorous activities. The questions are arranged in order of increasing physical demand, relevant to low back pain. Each of these 12 items is rated according to a continuous scale (0–100). The DR-index is calculated as the mean of the 12 items (i.e. the DR-index is a continuous scale and can vary between 0 and 100; a high value denotes high disability). The items include:

1. Dressing (unaided)
2. Out-door walks
3. Climbing stairs
4. Sitting for a longer time
5. Standing bent over a sink
6. Carrying a bag
7. Making a bed
8. Running
9. Light work
10. Heavy work
11. Lifting heavy objects and
12. Participating in exercise/sports.

The subjects were also asked to answer complementary items concerning mainly ADL items with the same focus on the lower back as the DR-index:

1. Rising from seated
2. Driving a car
3. Standing for a long while

Table I. *Sagittal mobility of the spine and posture groups according to the kyphyometry, joint mobility according to the Beighton score (trichotomized) and segmental mobility and pain provocation tests at L4–S1 levels (summarized from (14))*

Variables		*n*	Mean	SD
Sagittal mobility				
Sagittal thoracic mobility (°)		605	35.3	10.6
Sagittal lumbar mobility (°)		605	71.0	13.4
Lumbar extension (°)		605	49.1	10.1
Lumbar flexion (°)		605	21.9	9.3
Variables		***n***	**Percent (%)**	**Cumul. Percent (%)**
Posture				
Normal posture		507	83.53	83.53
Hyper curvature		28	4.61	88.14
Hypo curvature		22	3.62	91.76
Hyper kyphosis		35	5.77	97.53
Hyper lordosis		14	2.31	99.84
Missing		1	0.16	100.00
Beighton (trichtomized)				
Normal (0-2p)		437	71.99	71.99
Mild hyper (3-4p)		108	17.79	89.79
Prominent hyper (>4p)		62	10.21	100.00
Segmental mobility				
L4-L5	Hypo	75	12.4	12.4
	Normal	444	73.3	85.6
	Hyper	87	14.4	100.0
L5-S1	Hypo	116	19.1	19.1
	Normal	393	64.9	84.0
	Hyper	97	16.0	100.0
Pain provocation				
L4-L5	No	474	78.2	78.2
	Yes	132	21.8	100.0
L5-S1	No	472	77.9	77.9
	Yes	134	22.1	100.0

Table II. *Items of disability together with the disability rating index (DR-index) and lumbar index (L-index).* n, *mean, 1 SD and median are given for each item and the two indices*

Items and indices	Valid N	Mean	SD	Median
ADL items				
Dressing (unaided)	607	6	12	2
Outdoor walks	607	9	15	3
Climbing stairs	607	11	17	3
Sitting for a longer time	607	21	24	11
Standing bent over a sink	607	19	23	9
Carrying a bag	607	23	24	14
Making a bed	607	16	21	8
Running	606	25	30	11
Light work	607	8	14	3
Heavy work	607	25	25	17
Lifting heavy objects	607	33	28	27
Participating in exercise/sports	607	20	24	9
Disability Rating index	606	18	16	14
Complementary ADL items				
Rising from seated	607	11	17	3
Driving a car	594	10	19	3
Standing a long while	607	17	21	8
Bending forward	607	15	21	6
Rising from forward bending	607	17	22	7
Lying prone	607	20	29	5
Lying supine	607	11	18	3
Lying on one's side in bed	607	9	16	3
Going up a hill	607	12	17	4
Going down a hill	606	10	16	3
How much exercise	607	64	26	69
How manage physical exercise	607	29	29	18
Managing housework	607	14	17	7
Managing at work	607	16	19	9.5
Lumbar index	607	15	15	11.4

4. Bending forward
5. Rising from forward bending
6. Lying prone
7. Lying supine
8. Lying on one's side in bed
9. Going up a hill
10. Going down a hill
11. How much do you exercise?
12. How do you manage your physical training now?
13. How do you manage housework? and
14. How do you manage at work?

Among the ADL items and the complementary ADL items (cf. Table II) the 8 items with strongest correlations with low back strain and pain intensity were identified (i.e. the items: "out door walks" and "sitting for a longer time" of the ADL items and "standing a long while", "bending forward", "rising from forward bending", "lying prone", "managing housework" and "managing at work" from the complementary ADL items) are summarized as the "*lumbar index*" (abbreviated as the L-index) which is the mean of these measurements expressed in percent of the highest possible rating.

2. Clinical examinations by three experienced physiotherapists according to a predetermined schedule consisting of:

A. Segmental mobility and segmental pain provocation

The manual segmental mobility and pain provocation tests, regarded as the most subjective part of the examination, were always carried out first, with the patient lying on her side, with hips and knees flexed, and the examiner standing; mobility of *five passive movements* of each segment out of the eight from the lumbosacral segment up to T10–T11 was tested; i.e. forward and backward bending, rotation right and left and translatoric joint play (labelled gliding). The lumbosacral segment was defined as segment L5–S1. The segmental mobility was estimated, from the neutral position, by stepwise interspinal palpation. Any tenderness/pain during each part of the testing was recorded and defined as pain provocation (which in this study was considered as a sign). From the five passive movements, the examiner rated the *segmental mobility* using a 5-point scale: +2 = extreme hypermobility, + 1 = moderate hypermobility, 0 = normal mobility, −1 = moderate hypomobility, and −2 = extreme hypomobility. No predetermined criteria for the segmental mobility with respect to the five passive movements were used. However, a regression analysis showed that this sign was based mainly upon sagittal movement and by left and right rotation ($R^2 = 0.85$–0.88; $n = 606$) (14). The segmental pain provocation was determined according to: +1 = pain and 0 = no pain. In the present study the results from the two levels with highest prevalences of non-normal findings will be used (i.e. L4–L5 and L5–S1) (14).

B. Spinal sagittal posture and sagittal thoracic and lumbar mobility

Debrunner's kyphometer was used for measurements of spinal sagittal configuration and spinal (thoracic and lumbar) sagittal mobility (17) in the standing position. The kyphometer has a protractor with a 1° scale (80° to 0° to minus 70°) at the end of two double, parallel arms connected to two blocks (17). The blocks are large enough to span two spinous processes. A total of 606 subjects participated in this part of the study; data were incomplete for one subject. The neutral zero starting position was defined as the configuration in the erect standing relaxed position, arms hanging down and barefoot heels, 10 cm apart.

Spinal sagittal posture. Kyphosis was measured from a point between the spinous processes of T2 and T3 and from a second point between T11 and T12. Lordosis was measured between T11–T12 and S1–S2. The degrees of kyphosis and lordosis were read directly from the scale. A scheme was used for the classification of body posture (18).

Sagittal thoracic and lumbar mobility. The sagittal range of motions was determined separately in the lumbar and thoracic spine. Total backward and forward bending from neutral position was recorded and the total sagittal range of movement was calculated.

C. Joint mobility

Joint mobility (mainly peripheral) was assessed using the modified Beighton score (0–9 points) (19):

1. Passive dorsiflexion of MCP 5 beyond 90°
2. Passive apposition of the thumb to the flexor aspect of the forearms
3. hyperextension of the elbow beyond 10°
4. Hyperextension of the knees beyond 10°
5. Forward flexion of the trunk, with knees straight, so that the palms of the hands rest easily on the floor.

Mild generalized joint hypermobility was defined as a score of 3–4 and *prominent* generalized hypermobility as ≥ 5 (i.e. a trichotomized score).

Statistics

All statistics were performed using the statistical package STATISTICA for Windows (version 5.1) or SIMCA (version 6.01). For variables and indices, mean values ± one standard deviation (±1 SD) are generally reported. To evaluate differences between groups Student's *t*-test and one-way analysis of variance (ANOVA and *post hoc* tests) were used. The χ^2 test was performed to evaluate differences in distribution between groups. Cluster analysis (based on the K-means algorithm) was used to classify the subjects into subsets containing subjects with similar characteristics, thus identifying subgroups. The identified subgroups were then compared with respect to different variables using ANOVA. Principal component analysis (PCA) (using SIMCA) was used to detect whether a number of variables reflect a smaller number of underlying factors (20). Thus, PCA can be viewed as a multivariate correlation analysis (see (20) for a brief introduction). Components of the PCA with eigenvalues ≥1.00 (Kaiser's criterion) were considered as non-trivial factors. Loadings indicate the relationships between the variables and scores the relationships between subjects. Variables loading upon the same component are correlated and the loading expresses the degree of correlation between the item and the component. Regression analyses were made according to the partial least-square technique (PLS) (see (20) for a brief explanation of this regression technique). The aim of using PLS regression in the present study was to regress two Y variables (DR-index and L-index) using other variables (the X variables, i.e. mobility and posture signs and symptom variables (pain and strain) and age) as regressors. PLS finds the relationship between a matrix Y (dependent variables) and a matrix X. PLS modelling consists of simultaneous projections of both the X and Y spaces on low dimensional hyper planes. The coordinates of the points on these hyperplanes constitute the elements of the matrices T and U. The relationship between T- and U scores is a summary of the relationship between X and Y along a specific model component. The VIP variable (variable influence on projection) gives information about the relevance of each X variable and each Y variable pooled over all dimensions and VIP > 1.0 is significant (20). Multiple linear regression could have been used as an alternative method for the prediction but it assumes that the regressor variables are mathematically independent. If such multicolinearity occurs among the X variables, the calculated regression coefficients become unstable and their interpretability breaks down (20).

All statistical tests were performed at the 5% significance level ($p \leq 0.05$, two-tailed).

RESULTS

Sociodemographic and anthropometric data

Sociodemographic and anthropometric data for the present subjects have recently been reported in greater detail (14). The mean age was 40.5 ± 11.9 years and the subjects had worked, as a group, for more than 10 years (mean) for the healthcare authority (14).

Impairments

Signs. Results from the joint mobility, posture and sagittal mobility and segmental mobility and pain provocation have been presented in detail elsewhere (14) and the results are summarized in Table I.

Symptoms. In our study 56.9% of our subjects reported previous low back pain problems and 47.8% low back pain on one or several days during the past week. There was no significant relation between age and low back pain prevalence and intensity (Fig. 1). Pain intensity and strain during work and during leisure were most intense in the low back (mean values: 34 mm, 56 mm and 34 mm) followed by the neck (mean values: 26 mm, 42 mm and 25 mm) and shoulder regions (mean values: 26 mm, 47 mm and 26 mm). Anatomical regions included in the analysis below are: the upper back, lower back and hips regions.

Disability

Seventy percent of our subjects reported fewer than 8 days of incapacity benefit during the previous 12 months. Corresponding prevalences for 8–29 days, 30–59 days, 60–90 days and >90 days were: 16.8%, 3.1%, 1.2% and 5.3%, respectively. Owing to low back pain, 11.4% reported incapacity benefit on one or several occasions during the previous three years. The ability to perform certain activities mainly within the field of ADL functions is shown in Table II. In the DR-index heavy lifting, heavy physical work and carrying are the items with the highest level of difficulty. Among the complementary ADL items, the two exercise variables were particularly associated with difficulties.

Signs versus disabilities

Joint mobility. Only "lying prone" ($p = 0.039$) and "going up a hill" ($p = 0.038$) of the *disability items* listed in Table II showed any significance between the groups from the trichotomized Beighton score.

Thoracic and lumbar sagittal posture. The items "running" ($p = 0.025$), "sporting difficulty" ($p = 0.004$), "rising from seated" ($p = 0.038$), "going up a hill" ($p = 0.001$) differed significantly between the different posture groups. The *post hoc* tests indicated that difficulties in going up a hill were significantly related to *hyper curvatures*.

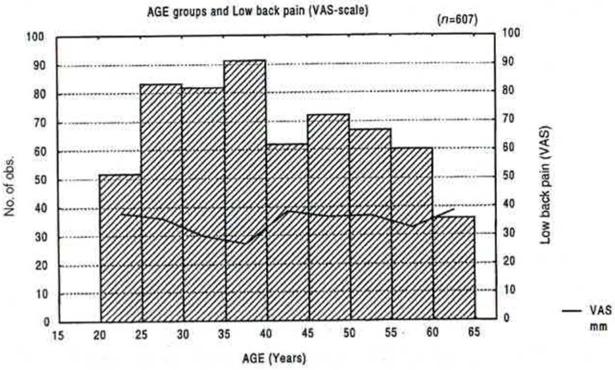

Fig. 1. Absolute numbers of subjects in different age groups (bars) together with average pain intensity (according to VAS (mm; line)) in 607 female homecare personnel.

Table III. *Lumbar sagittal mobility (trichotomized using ±1 SD as cut-offs) versus the disability items and the disability rating index (DR-index) and lumbar-index (L-index). Significant differences according to ANOVA* (p-values given) *exist for all items and the two indices. The post hoc comparisons are shown in bold type if significant versus normal (denoted as post hoc* p)

Items and Indices	Hypo	Normal	Hyper	ANOVA *p*-value
Dressing (unaided)	9.9	6.2	4.0	0.001
post hoc *p*	**0.013**		0.206	
Outdoor walks	12.8	8.1	7.2	0.013
post hoc *p*	**0.016**		0.861	
Climbing stairs	16.3	9.6	9.1	0.001
post hoc *p*	**0.001**		0.956	
Sitting for a longer time	29.8	19.5	18.2	0.000
post hoc *p*	**0.000**		0.869	
Standing bent over a sink	27.8	17.5	15.4	0.000
post hoc *p*	**0.000**		0.665	
Carrying a bag	28.4	22.9	15.6	0.001
post hoc *p*	0.097		**0.014**	
Making a bed	24.8	15.6	11.5	0.000
post hoc *p*	**0.000**		0.159	
Running	42.7	23.4	17.2	0.000
post hoc *p*	**0.000**		0.133	
Light work	12.1	8.3	5.1	0.001
post hoc *p*	**0.036**		0.076	
Heavy work	33.3	25.0	17.9	0.000
post hoc *p*	**0.009**		**0.028**	
Lifting heavy objects	43.1	32.5	22.5	0.000
post hoc *p*	**0.002**		**0.003**	
Participating in exercise/sports	31.8	18.5	11.9	0.000
post hoc *p*	**0.000**		**0.030**	
DR-index	25.9	17.3	13.0	0.000
post hoc *p*	**0.000**		**0.029**	
Rising from seated	19.8	10.2	6.5	0.000
post hoc *p*	**0.000**		0.124	
Standing a long while	23.1	16.5	13.3	0.003
post hoc *p*	**0.013**		0.356	
Bending forward	22.5	14.1	10.9	0.000
post hoc *p*	**0.001**		0.351	
Rising from forward bending	24.7	16.6	12.3	0.000
post hoc *p*	**0.003**		0.182	
Lying prone	27.3	20.6	12.0	0.001
post hoc *p*	0.091		**0.017**	
Lying supine	17.0	11.1	7.1	0.001
post hoc *p*	**0.011**		0.123	
Going up a hill	19.8	10.6	6.8	0.000
post hoc *p*	**0.000**		0.091	
Going down a hill	16.3	10.1	5.8	0.000
post hoc *p*	**0.002**		**0.037**	
Managing physical exercise	36.4	29.2	21.0	0.001
post hoc *p*	0.074		**0.031**	
Managing at work	20.9	15.6	12.5	0.007
post hoc *p*	**0.038**		0.292	
L-index	22.2	15.6	12.0	0.000
post hoc *p*	**0.001**		0.091	

Thoracic and lumbar sagittal mobility. For the sign *thoracic sagittal mobility* (trichotomized using ±1 SD as cut-offs), only "manage physical exercise" of the disability items showed significance ($F = 3.39$, $p = 0.034$).

For the trichotomized (±1 SD as cut-offs) *lumbar sagittal mobility,* all items and indices showed significant differences (Table III). Hypomobility was associated with significantly higher scores on the disability items and the two indices.

Segmental mobility. Markedly significant differences for both L4-L5 and L5-S1 levels were found for "sitting", "bending forward", "rising from forward bending", "managing house-work", "lying prone", on the DR-index and the L-index (Table IV). Bi-phasic patterns were found for most disability items, with higher scores for both hyper- and hypomobility. To summarize: the *post hoc* tests showed that significantly higher scores existed for the hypomobility group than for the normal group at both L4–L5 and L5–S1 levels. There were also significant differences between the hypermobility group and the normal group in many items, with higher scores for the hypermobility group especially in the lumbar index, managing

Table IV. *Segmental mobility of L4–L5 and L5–S1 with respect to the items of disability. ANOVA has been used for evaluating differences between the three groups (p-values are given and * denotes significant difference). If significant, the following post hoc comparisons have been made: hypomobility versus normal and hypermobility versus normal, respectively (* after mean value indicates significant post hoc test)*

Items and indices	L4-L5 Hypo	Normal	Hyper	ANOVA *p*-value	L5-S1 Hypo	Normal	Hyper	ANOVA *p*-value
ADL items								
Dressing (unaided)	8.0	5.6	9.3*	0.012*	10.2*	5.1	7.1	0.000*
Outdoor walks	12.4*	7.4	11.7*	0.003*	10.9	7.6	10.0	0.080
Climbing stairs	12.9	9.6	13.9	0.045*	14.8*	9.7	9.6	0.011*
Sitting for a longer time	24.8	18.8	28.7*	0.001*	29.8*	17.6	24.1*	0.000*
Standing bent over a sink	24.5*	17.2	22.7	0.009*	24.7*	16.5	21.8	0.001*
Carrying a bag	24.9	21.6	26.4	0.164	26.5	21.3	23.9	0.103
Making a bed	19.5	14.8	22.5*	0.003*	19.3	14.9	19.4	0.042*
Running	34.1*	23.7	27.2	0.018*	34.8*	22.7	25.6	0.001*
Light work	11.1	7.5	10.7	0.026*	10.2	7.4	10.0	0.062
Heavy work	28.0	24.3	28.2	0.249	29.2	23.6	27.5	0.072
Lifting heavy objects	39.1*	31.0	35.7	0.036*	39.0*	30.7	32.7	0.019*
Participating in exercise/sports	26.1*	18.4	19.8	0.039*	27.6*	17.7	17.7	0.000*
DR-index	22.1*	16.6	21.4*	0.002*	22.9*	16.2	19.1	0.000*
Complementary ADL items								
Rising from seated	15.1	9.8	14.8	0.004*	15.4	9.7	12.2	0.005*
Driving a car	11.9	9.7	10.7	0.620	13.3	8.8	11.7	0.054
Standing for a long while	20.9	16.1	19.0	0.123	21.8*	15.4	18.4	0.011*
Bending forward	21.0*	13.1	19.7*	0.001*	20.9*	12.5	18.1*	0.000*
Rising from forward bending	25.0*	15.0	21.9*	0.000*	24.8*	14.4	19.6	0.000*
Lying prone	30.4*	18.3	21.3	0.003*	27.1*	17.2	23.9	0.002*
Lying supine	12.6	10.6	14.3	0.187	14.8*	9.7	14.0	0.009*
Lying on one's side in bed	13.4*	8.1	8.9	0.030*	13.7*	7.4	9.0	0.001*
Going up a hill	16.4*	10.0	14.6	0.002*	15.4*	10.2	11.9	0.015*
Going down a hill	17.4*	8.9	12.3	0.000*	14.3*	8.7	12.9*	0.001*
How much exercise	64.8	63.3	63.9	0.896	65.8	62.6	64.6	0.475
Managing physical exercise	29.1	29.2	28.5	0.979	33.6	28.5	25.9	0.134
Managing housework	16.3	12.3	19.0*	0.002*	16.1	12.1	17.6*	0.006*
Managing at work	17.8	15.2	18.0	0.285	18.3	14.3	19.7*	0.013*
L-index	21.1*	14.5	19.9*	0.000*	21.2*	13.9	18.9*	0.000*

housework and bending forward (Table IV). An exception was "difficulty with sports", where the hypomobility group had high scores while the hypermobility group did not differ from the normal mobility group.

Segmental pain provocation tests. There were markedly significant differences between those with negative and those with positive pain provocation tests for all the disability items and the two indices at both levels (Table V). A significant difference in the prevalence of positive pain provocation was found in the different categories of incapacity benefit both at L4–L5 ($F = 2.92$, $p = 0.033$) and at L5–S1 ($F = 4.25$, $p = 0.006$). For example, the prevalence of the positive pain provocation test at L5–S1 increased with number of benefit days during the previous 12 months; 0 days: 17.0%, 1–7 days: 20.0%, 8–29 days: 31.4%, ≥30 days: 32.8%.

Multivariate analysis based on impairments and disabilities

A PLS regression was made in order to regress the DR-index and L-index simultaneously (Y variables) using the pain intensity variables and the strain variables of the relevant anatomical regions (upper back, lower back and hips), the mobility signs and segmental pain provocation tests together with age as predictors (X variables). A significant model could be established ($R^2 = 0.34$) (Table VI); the pain intensity variables had the greatest significant importance as regressors but the pain provocation tests were also significant (i.e. VIP > 1.0).

In order further to elucidate how the signs of mobility influenced symptoms and disabilities, a cluster analysis (three clusters) was made based on the signs (Table VII). The first cluster ($n = 99$) had the least mobility and highest incidences of positive pain provocation tests. The second cluster ($n = 386$) was intermediate with respect to total sagittal mobility, Beighton score, and segmental mobility and had very low prevalences of positive pain provocation tests. The third cluster ($n = 120$) had the greatest mobility and intermediary levels of positive pain provocation according tests to the segmental tests. From the statistical evaluation it was obvious that the individuals belonging to the first cluster were older, had higher pain intensities and strain and the highest levels of disability (DR-index and L-index). The most unfavourable situation was considered to be, having little sagittal mobility and having positive pain provocation tests.

The pain provocation tests at L4–S1 alone were then used as the basis for the formation of clusters. The first cluster ($n = 432$) had negative pain provocation tests. The second cluster ($n = 42$) had positive pain provocation tests only at the lower level and the third cluster ($n = 132$) generally had positive pain provoca-

Table V. *Segmental pain provocation tests at L4–L5 and L5–S1 levels versus the disability items, disability rating index (DR-index) and lumbar index (L-index). Student's* t-test *was used in the statistical evaluation (p-values are given)*

Items and indices	L4-L5 Negative	Positive	*p*-value	L5-S1 Negative	Positive	*p*-value
ADL items						
Dressing (unaided)	5.5	9.5	0.000	5.5	9.5	0.000
Outdoor walks	7.1	14.0	0.000	6.8	15.1	0.000
Climbing stairs	9.2	15.7	0.000	9.2	15.7	0.000
Sitting longer time	16.9	35.5	0.000	17.6	32.8	0.000
Standing bent over a sink	15.3	31.8	0.000	15.7	30.0	0.000
Carrying a bag	20.3	31.3	0.000	20.2	31.5	0.000
Making a bed	13.3	27.9	0.000	13.8	25.8	0.000
Running	22.6	36.0	0.000	23.0	34.3	0.000
Light work	7.5	11.5	0.003	7.4	12.0	0.001
Heavy work	22.2	36.3	0.000	22.4	35.6	0.000
Lifting heavy objects	29.2	44.9	0.000	29.3	44.4	0.000
Participating in exercise/sports	17.8	26.0	0.001	18.0	25.2	0.002
DR-index	15.5	26.7	0.000	15.7	26.0	0.000
Complementary ADL items						
Rising from seated	8.6	20.3	0.000	9.0	18.8	0.000
Driving a car	9.0	14.3	0.004	9.1	13.5	0.000
Standing for a long while	14.8	25.3	0.000	15.1	24.2	0.000
Bending forward	11.3	28.2	0.000	11.5	27.3	0.000
Rising from forward bending	13.5	30.8	0.000	13.8	29.3	0.000
Lying prone	17.0	31.6	0.000	17.2	30.9	0.000
Lying supine	9.0	19.7	0.000	8.8	20.2	0.000
Lying on one's side in bed	7.5	13.8	0.000	7.6	13.2	0.000
Going up a hill	9.9	17.1	0.000	9.9	17.1	0.000
Going down a hill	9.4	14.3	0.002	8.9	15.7	0.000
How much exercise	61.9	69.5	0.003	62.2	68.5	0.000
Managing physical exercise	27.5	34.7	0.012	27.4	34.8	0.000
Managing housework	12.0	20.0	0.000	11.9	20.2	0.000
Managing at work	14.1	22.5	0.000	13.8	23.4	0.000
L-index	13.3	26.0	0.000	13.5	25.4	0.000

tion tests at both levels (Table VIII). Positive pain provocation tests at two levels (i.e. membership of cluster 3) were associated with higher pain and strain intensities than membership of the other two clusters. Positive pain provocation at the lower segmental level (i.e. the third cluster) showed intermediary increased levels compared with the subgroup without positive tests at any level (i.e. the first cluster).

Based on the variables with greatest variance according to a principal component analysis (PCA; not presented) (i.e. pain provocation L4-L5 and total lumbar sagittal mobility), a final cluster analysis was made (Table IX). The first cluster ($n = 473$) was characterized by intermediary lumbar mobility and negative pain provocation tests at the L4–L5 level. The second cluster ($n = 70$) was characterized by high lumbar sagittal mobility and positive pain provocation at the L4–L5 level and the third cluster ($n = 62$) by low lumbar sagittal mobility and positive pain provocation tests at the L4–L5 level. By means of this analysis, we identified two clusters (clusters 2 and 3) with positive pain provocation but on average a more than 20° difference in lumbar sagittal mobility. No marked differences in pain and strain intensities existed but the disability ratings were highest when positive pain provocation existed together with low lumbar sagittal mobility (cluster 3).

Table VI. *Regression of disability rating index (DR-index) and lumbar index (L-index) (Y variables) using the mobility and posture signs and symptom variables (pain and strain) together with age as X variables. The variable influence on variation (VIP) is given for each variable, and coefficient (i.e. PLS scaled and centred regression coefficients; denoted as Coeff.). VIP > 1.0 is significant. VIP > 1.0 is significant (above the dotted line).* R^2 *is also given*

Signs and symptoms	VIP	DR-index (Coeff.)	L-index Coeff.)
Pain intensity low back	1.89	0.14	0.15
Pain intensity hips	1.86	0.14	0.15
Pain intensity upper back	1.49	0.11	0.12
Pain Provocation L4-L5	1.22	0.09	0.10
Pain Provocation L5-S1	1.14	0.09	0.09
Strain leisure low back	1.05	0.08	0.08
Sagittal lumbar mobility	0.88	−0.07	−0.07
Age	0.85	0.06	0.07
Strain work low back	0.81	0.06	0.06
Strain leisure hips	0.80	0.06	0.06
Strain work hips	0.67	0.05	0.05
Strain leisure upper back	0.54	0.04	0.04
Strain work upper back	0.35	0.03	0.03
Sagittal thoracic mobility	0.32	−0.02	−0.02
Segmental mobility L5-S1	0.27	−0.02	−0.02
Beighton score	0.21	−0.02	−0.02
Segmental mobility L4-L5	0.02	0.00	0.00
R^2	0.34		

Table VII. *Cluster analysis based upon sagittal mobility, joint mobility (Beighton score) and segmental tests (segmental mobility and pain provocation) (above the dotted line). The three identified clusters have been compared for age, symptoms (pain and strain) and disabilities (DR-index, L-index and sick leave) using ANOVA (below the dotted line). Incapacity benefit was categorized in four classes (≥30 days taken together). F-values and* p-*values are given*

Cluster Variable	Cluster 1 ($n = 99$) Mean	SD	Cluster 2 Mean	($n = 386$) SD	Cluster 3 Mean	($n = 120$) SD	ANOVA F-value	*p*-value
Sagittal thoracic mobility (°)	30.3	11.2	34.6	9.7	41.6	10.0	37.3	0.000*
Sagittal lumbar mobility (°)	62.7	11.8	70.6	12.9	79.2	11.9	47.8	0.000*
Beighton score	1.1	1.4	1.4	1.6	4.1	2.3	118.2	0.000*
Segmental mobility L4-L5	−0.1	0.6	−0.1	0.4	0.4	0.6	48.9	0.000*
Segmental mobility L5-S1	−0.3	0.6	−0.2	0.5	0.6	0.5	120.7	0.000*
Pain provocation L4-L5	0.7	0.5	0.0	0.1	0.5	0.5	307.1	0.000*
Pain provocation L5-S1	0.7	0.4	0.0	0.1	0.5	0.5	319.0	0.000*
Age (years)	45.7	11.3	40.7	11.8	35.7	10.4	20.9	0.000*
Pain upper back (mm)	26.4	23.6	18.9	22.7	22.4	24.2	4.4	0.012*
Pain low back (mm)	52.5	27.8	27.9	25.3	39.4	28.7	37.1	0.000*
Pain hips (mm)	27.3	26.5	11.4	16.8	16.8	24.3	24.4	0.000*
Strain work upper back (mm)	45.6	28.3	44.7	28.6	51.7	27.7	2.8	0.061
Strain work low back (mm)	66.6	24.2	51.4	27.6	60.3	27.7	14.6	0.000*
Strain work hips (mm)	42.4	26.2	35.2	27.4	39.0	29.4	3.0	0.049*
Strain leisure upper back (mm)	28.5	24.0	24.9	23.0	25.5	21.9	0.9	0.393
Strain leisure low back (mm)	44.1	28.4	30.3	24.4	37.7	28.1	12.7	0.000*
Strain leisure hips (mm)	26.7	23.1	21.6	21.8	22.7	24.1	2.0	0.133
DR-index	28.7	17.2	15.1	13.3	17.9	17.1	33.2	0.000*
L-index	28.0	19.0	12.6	12.1	17.2	17.9	44.0	0.000*
Incapacity benefit (four classes)	1.1	1.1	0.9	0.9	1.1	0.8	4.3	0.014*

* Significant difference between the three clusters.

DISCUSSION

Subjects

Working in homecare is generally considered to be heavy and demanding and is therefore associated with high incidences of work-related accidents and diseases/illness (11–13). In the present sample the majority of female homecare personnel were actively employed and at the time of the investigation, levels of incapacity benefit were low; only 5.3% had been on

Table VIII. *Cluster analysis based upon segmental pain provocation tests (0 denotes negative and 1 denotes positive test) at L4-L5 and L5-S1 levels (above the dotted line). These three clusters have been compared with respect to age, other signs, symptoms (pain and strain) and disabilities using ANOVA (below the dotted line). Incapacity benefit was categorised in four classes (≥30 days taken together). F-values and p-values are given*

Cluster Variables	Cluster 1 ($n = 432$) Mean	SD	Cluster 2 Mean	($n = 42$) SD	Cluster 3 Mean	($n = 132$) SD	F-value	*p*-value
Pain provocation L4-L5	0.0	0.0	0.0	0.0	1.0	0.0		
Pain provocation L5-S1	0.0	0.0	1.0	0.0	0.7	0.5	827.2	0.000
Age (years)	40.2	11.8	41.2	11.0	41.4	12.3	0.6	0.526
Sagittal thoracic mobility (°)	35.2	10.3	31.9	14.1	36.5	10.1	3.0	0.048*
Sagittal lumbar mobility (°)	71.6	13.1	71.0	14.8	69.2	14.2	1.6	0.212
Beighton score	1.8	2.0	2.2	2.6	2.0	2.0	1.0	0.379
Segmental mobility L4–L5	0.0	0.4	−0.2	0.5	0.3	0.7	21.7	0.000*
Segmental mobility L5–S1	−0.1	0.5	0.1	0.7	0.1	0.8	5.9	0.003*
Pain upper back (mm)	18.8	22.6	22.4	22.2	27.1	24.7	6.7	0.001*
Pain low back (mm)	27.9	25.3	44.9	28.8	51.6	27.7	45.6	0.000*
Pain hips (mm)	11.5	17.0	19.3	23.8	25.6	27.6	25.3	0.000*
Strain work upper back (mm)	44.8	28.7	55.5	27.9	47.4	27.6	2.9	0.058
Strain work low back (mm)	51.6	28.2	68.8	22.1	64.2	24.8	16.2	0.000*
Strain work hips (mm)	35.4	28.0	44.2	24.6	40.3	27.5	3.1	0.045*
Strain leisure upper back (mm)	24.6	22.9	27.7	21.4	28.4	23.6	1.6	0.212
Strain leisure low back (mm)	30.7	24.8	40.4	26.7	43.1	28.8	13.0	0.000*
Strain leisure hips (mm)	21.6	21.9	25.3	24.1	25.3	23.8	1.7	0.190
DR-index	14.8	13.3	22.9	18.5	26.7	17.8	35.1	0.000*
L-index	12.5	12.3	22.4	20.3	26.0	19.0	47.3	0.000*
Incapacity benefit (four classes)	1.0	1.1	1.7	1.8	1.3	1.4	7.9	0.000*

* Significant difference between the three clusters.

Table IX. *Cluster analysis based on lumbar sagittal mobility and pain provocation tests at L4–L5 level (above the dotted line). These three clusters have been compared for age, other signs, symptoms (pain and strain) and disabilities using ANOVA (below the dotted line). Incapacity benefit was categorized in four classes (≥30 days taken together). F-values and p-values are given*

Cluster Variables	Cluster 1 Mean	(*n* = 473) SD	Cluster 2 Mean	(*n* = 70) SD	Cluster 3 Mean	(*n* = 62) SD	F-value	*p*-value
Lumbar sagittal mobility (°)	71.54	13.20	79.80	7.89	57.31	9.37	56.29	0.000*
Pain provocation L4–L5	0.00	0.00	1.00	0.00	1.00	0.00		
Age (years)	40.23	11.74	37.23	11.29	46.15	11.71	10.10	0.000*
Sagittal thoracic mobility (°)	34.91	10.75	38.96	10.44	33.73	9.05	5.21	0.006*
Beighton score	1.86	2.06	2.37	2.05	1.68	1.91	2.34	0.097
Segmental mobility L4–L5	−0.05	0.44	0.46	0.56	0.03	0.72	31.85	0.000*
Segmental mobility L5–S1	−0.07	0.54	0.21	0.76	−0.03	0.72	7.03	0.001*
Pain provocation L5–S1	0.09	0.28	0.66	0.48	0.74	0.44	175.39	0.000*
Pain upper back (mm)	19.08	22.54	25.40	23.73	29.06	25.81	6.70	0.001*
Pain low back (mm)	29.37	26.06	50.13	27.51	53.32	27.93	36.85	0.000*
Pain hips (mm)	12.17	17.84	22.23	25.08	29.34	29.89	24.50	0.000*
Strain work upper back (mm)	45.88	28.74	51.37	25.94	42.98	28.87	1.58	0.206
Strain work low back (mm)	53.26	28.04	65.99	22.69	62.18	27.00	8.55	0.000*
Strain work hips (mm)	36.25	27.74	40.44	27.11	40.18	28.07	1.11	0.329
Strain leisure upper back (mm)	24.85	22.73	26.50	21.96	30.56	25.42	1.76	0.174
Strain leisure low back (mm)	31.51	25.08	39.53	28.18	47.03	29.16	11.64	0.000*
Strain leisure hips (mm)	21.90	22.10	21.80	20.65	29.26	26.56	3.00	0.050*
DR-index	15.46	13.94	23.44	17.17	30.35	17.92	33.33	0.000*
L-index	13.28	13.40	22.02	16.84	30.46	20.43	44.08	0.000*
Incapacity benefit (four classes)	0.91	0.88	1.06	0.87	1.15	1.10	2.12	0.121

* Significant difference between the three clusters.

incapacity benefit >90 days during the previous 12 months. These relatively low figures were probably due to a combination of reorganization within the healthcare system a few years earlier in Sweden (those with more extensive incapacity benefit periods applied to benefit claims had been granted permanent or temporary disability pensions) and changes in the rules concerning sick leave. It is thus likely that a healthy worker effect exists, even though we were not able (owing to the reorganization) to estimate its magnitude.

Signs versus disability

Both thoracic sagittal mobility and general joint mobility (according to the Beighton score) showed poor correlation with the disability items and indices used.

Lumbar sagittal mobility was associated with marked and significant differences in all disability items and the two disability indices. Hypomobility showed significantly higher disability compared with ordinary mobility. The group with hypermobility had less disability (i.e. DR-index and six of the items) than the group with normal mobility, and for the other items and the L-index, similar non-significant trends were noted. Based upon the present cross-sectional study, being hypermobile is a positive factor regarding disability in daily life. If pain had correlated with hypomobility, this would have confounded such a conclusion, but this was not the case. Our results are in agreement with the those of Salminen et al., who reported a significant correlation between spinal mobility and leisure time physical activity in 15-year-old subjects (21). By contrast, Grönblad and co-workers did not find any correlation with disability assessments in 52 patients with chronic low back pain (22). Similar conclusions to those of Grönblad et al. have also been drawn in other studies of industrial employees (23) and of subjects with acute back pain (24).

Positive segmental pain provocation tests (Table V) and segmental hypomobility (Table IV) were significantly associated with high disability levels. Moreover, in contrast to lumbar sagittal hypermobility, segmental hypermobility generally was associated with significantly elevated disability levels (Table IV).

In regression analysis the segmental pain provocation tests were of greater importance than the thoracic or lumbar sagittal mobility in the prediction of DR-index and L-index (Table VI). But the principal pattern, that pain provocation had greater importance than lumbar sagittal mobility, remained even when the pain intensity variables were included in the prediction model (Table VI). In fact, neither thoracic nor lumbar sagittal mobility, segmental mobility nor joint mobility (Beighton score) had any significant influence in the multivariate context upon the two disability indices. Against these results it could be argued that the explained variance from a predictive point of view was low.

When the positive pain provocation tests at the L4–S1 levels were used as the base for the subgrouping (Table VIII), it was evident that positive pain provocation tests at one or two out of two levels (clusters 2 and 3) were associated with increased levels of disability. In short, the segmental pain provocation tests appeared to be more strongly correlated with disability than the other signs used in the present study.

Since lumbar sagittal mobility and pain provocation were not correlated but showed separate relationships with disability (c.f.

Tables III and V), it was reasonable to combine these as a basis for a cluster analysis (Table IX). As expected, having intermediary lumbar sagittal mobility and a negative pain provocation test (cluster 1) was the most favourable situation from the disability point of view. Both of the other two clusters had positive pain provocation tests along with hypermobility (cluster 2) or hypomobility (cluster 3). Subjects in the third cluster were approximately 10 years older than those in cluster 2, and had higher disability levels. Positive pain provocation tests at L4–S1 and lumbar sagittal hypomobility appeared to be independent indicators of relatively high disability levels.

Even though the present study has clearly indicated significant correlations between certain signs and aspects of disability, it can be argued that the psychometric properties of the DR- and L-indexes have not been elucidated. In future studies it is important to use disability indices with known and good psychometric properties.

CONCLUSION

In conclusion, the segmental pain provocation tests at L4–L5 and L5–S1 levels were more strongly correlated with disability than the other signs used in the present study. Lumbar sagittal mobility and segmental mobility (L4–L5 and L5–S1) levels showed relatively high associations with disability.

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