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CLINICAL SYMPTOMS RELATED TO MUSCULOSKELETAL NECK–SHOULDER PAIN AND MOBILITY IN THE CERVICO-THORACIC SPINE

Staffan Norlander, RPT[1,2] and Bengt Nordgren, MD, PhD[2]

From the [1]Research Foundation for Occupational Safety and Health in the Swedish Construction Industry, Stockholm and [2]Department of Rehabilitation Medicine, University Hospital, Uppsala University, Uppsala, Sweden

ABSTRACT. **In a cross-sectional study 142 male and 139 female workers participated in a self-report questionnaire and a clinical examination. The aim of this study was to use the cervico-thoracic ratio (CTR), a clinical method for measuring segmental mobility between C7 and T5, to evaluate the influence of segmental mobility in neck-shoulder pain and different subjectively experienced symptoms. The study showed that reduced relative mobility at levels C7–T1 and T1–T2 significantly predicted neck-shoulder pain and the symptom weakness in the hands. The strongest relationship between segmental mobility and symptoms was found among subjects classified as having an inverse C7–T1 function, defined as equal or less mobility in motion segment C7–T1 compared to T1–T2. Reduced mobility explained 14% of neck-shoulder pain and 15% of weakness in the hands. It is suggested that deviation from synchronous distribution of mobility between motion segments C7–T1 and T1–T2 might be a factor provoking joint mechano receptors.**

Key words: distribution, neck-shoulder pain, segmental mobility, weakness in the hands.

INTRODUCTION

Several studies indicate that injuries of the intervertebral joints, the discs, muscles and ligaments in the cervical spine can give rise to neck-shoulder pain (NSP), and also to various other symptoms, for instance paresthesia, headache or dizziness (2–3). The cause of these symptoms is often difficult to interpret because they do not always follow a distinct distribution corresponding to a spinal nerve root. Instead, they are indistinctly distributed and are often intermittent and thereby difficult to visualize as objective radiological or neurophysiological signs (2, 18). Nevertheless, subjective symptoms must be regarded as "genuine". To deal with this problem clinical methods have to be improved in order to clarify possible underlying causes.

A much-debated problem in the literature is the significance of spinal mobility in musculoskeletal disorders. The question is whether a person who experiences pain has increased, decreased or non-affected spinal mobility. Usually only the entire range including several segments of spinal mobility is measured. Increases and/or decreases at the segmental level are often neglected, resulting in a measurement showing a "normal" range of total spinal mobility. However, a new method, the cervico-thoracic ratio (CTR) might at least partly solve these problems, as mobility can be measured and assessed for a single motion segment separately (21–22). The CTR is developed to measure and assess the distribution of segmental flexion mobility in the cervico-thoracic articulations between C7 and T5. The method provides a concept for classification of segmental mobility in the classes hyper-, hypo- and ordinary mobility, respectively (21). Mobility classes are defined from a population of healthy subjects and consequently are not regarded as having "pathological" mobility even if NSP has been shown to be more frequent among subjects with hypomobility at level C7–T1 (22). The CTR method has also been used in a prospective two-year follow-up study where it was shown that an ordinary sequence of C7–T1 mobility gradually could change and develop into a dysfunction, defined as inverse C7–T1 function (24). The inverse C7–T1 function was shown to be a fairly good predictor of certain NSP related to the cervico-thoracic articulations and in that sense it was shown that segmental mobility was a risk factor in the development of NSP (24). Experimental studies support the significance of joint mobility as an important factor in musculoskeletal disorders. In recent years joint afferents

have been shown to influence the g-muscle spindle system and thereby the regulation of muscle stiffness (8–11). Disturbances in joint mobility may consequently be an important factor and we take the view that the lack of objective measurements for assessing segmental mobility might be one of the reasons why the significance of spinal mobility in musculoskeletal disorders is not well documented.

The aim of this study was to use the CTR method to evaluate the influence of distribution of segmental mobility in the cervico-thoracic articulations between C7 and T5 on the different symptoms experienced including NSP.

MATERIAL AND METHODS

Study design

A total of 142 male electricians, mean age 35.0 (SD 12.6) years and 139 female laundry workers, mean age 38.8 (SD 11.3) years participated in a cross-sectional study. All subjects answered the standardized Nordic questionnaire (15) about musculoskeletal complaints and different questions about clinical symptoms (7) and mental stress (17). A physiotherapist examined their mobility according to the CTR technique (21). From this data the relationship was evaluated in a single blind design.

NSP was evaluated by the question: For how long during the previous 12 months have you had pain in the neck and/or shoulders? The answers were divided into five different categories: 1) 0 days; 2) 1–7 days; 3) 8–30 days; 4) >30 days, but not daily; and 5) daily and referred to as the NSP index (NSPI). Neck-shoulder pain was defined as NSPI >2. The somewhat more manifest period of 8–30 days (NSPI >2) was chosen as the definition of NSP, as a very short period of 1–7 days may be a consequence of a minor muscle strain not involving the intervertebral joints. This definition is based on the fact that present NSP reported during the last seven days showed a somewhat weaker relationship to segmental mobility, which may support our point of view (23). The factors age (AGE) and number of working years (WOR) were also evaluated.

The following five questions about clinical symptoms were asked: Have you at any time during the previous 12 months experienced: Paresthesia in the hands? Weakness in the hands? Dizziness? Headache? Pain in the region of the heart? Answers regarding clinical symptoms were divided into five different categories: 1) no, never; 2) no, seldom; 3) sometimes; 4) yes, often; and 5) yes, very often. Subjects with scores of 1–2 were defined as "no symptoms", >3 as "symptoms" and 4–5 as "severe symptoms".

Four questions were asked about the experience of mental stress. Do you find yourself rushing even when you have got plenty of time? Do you usually push yourself under pressure to get things done that you have made up your mind to do? Do you find it difficult to relax during your leisure time? Do you consider your job a mental strain? Mental stress was defined as an index of the summarized score of the questions divided by four. Answers regarding mental stress were divided into five different categories: 1) no, never; 2) no, seldom; 3) sometimes; 4) yes, often; and 5) yes, very often.

Measuring of mobility

The CTR technique has been described in order to measure the segmental flexion mobility in the cervico-thoracic articulations which can be looked upon as the functional prolongation of the cervical spine. The CTR technique describes what is defined as relative flexion mobility (CTR%), which is a calculated ratio based on absolute values of skin distraction between C7–T5. Marking the distance of 30 mm in an upright posture has been used as the definition of one motion segment, as the height of one disc and one thoracic vertebral body is approximately 30 mm, according to Kapandji (14).

Absolute flexion mobility is defined as the measured changes in millimetres between the 30 mm interdistant skin markings, marked from the vertex of the spinous process of C7 down to T5 and measured with a tape measure after a maximal forward flexion of the trunk and neck from an upright posture. The CTR technique has been described in a previous study by Norlander et al. (21), as well as the validity and the repeatability of the CTR technique (22).

Classification of mobility

The classification model for relative flexion mobility (21) was created so that the ordinary mobility class comprised 50% of the variation for relative flexion mobility in motion segments C7 to T5 in a mixed population of healthy female and male subjects. It also comprised the normal variation in relative flexion mobility caused by the individual factors age, height and body weight (21). The hyper- and hypomobility classes each comprised 25% of the mixed healthy population. In motion segment C7–T1 the limits of relative flexion mobility for the ordinary mobility class ranged from 21.2 to 22.5% of the total relative flexion mobility between C7 and T5. The hypermobility class C7–T1 was defined as relative flexion mobility greater than 22.5% and the hypomobility class as relative flexion mobility less than 21.2%. The ordinary CTR% limits for motion segments C7–T5 are shown in the shaded area (Fig. 1). The horizontal line at CTR 20% constitutes the starting-point for equal relations between all five motion segments C7–T5 (Fig. 1).

The degree of mobility between segments C7 and T1 is usually significantly greater than that between segments T1 and T2 (1). Inverse C7–T1 function is defined as having a greater or equal relative flexion mobility in motion segment T1–T2 compared with motion segment C7–T1. Such a deviation from the normal sequence of relative flexion mobility is defined as inverse C7–T1 function and regarded as a risk factor for development of NSP (23, 24).

Statistical analysis

The relationships between segmental mobility, symptoms and NSP were evaluated in a stepwise regression analysis. The beta coefficient and the R^2 value were presented for the different analyses. Additional variables included in the model were tested if they resulted in a significant increase in the accuracy of prediction according to McNemar (19). Minimal F-value to include or exclude a variable was 0.01.

1. The first step was to determine which of the chosen set of eight independent variables were the best predictors of the dependent variable neck-shoulder pain index (NSPI): paresthesia in the hands, weakness in the hands, dizziness, headache, pain in the region of the heart, mental stress, age and number of working years. The analysis was first done for all subjects

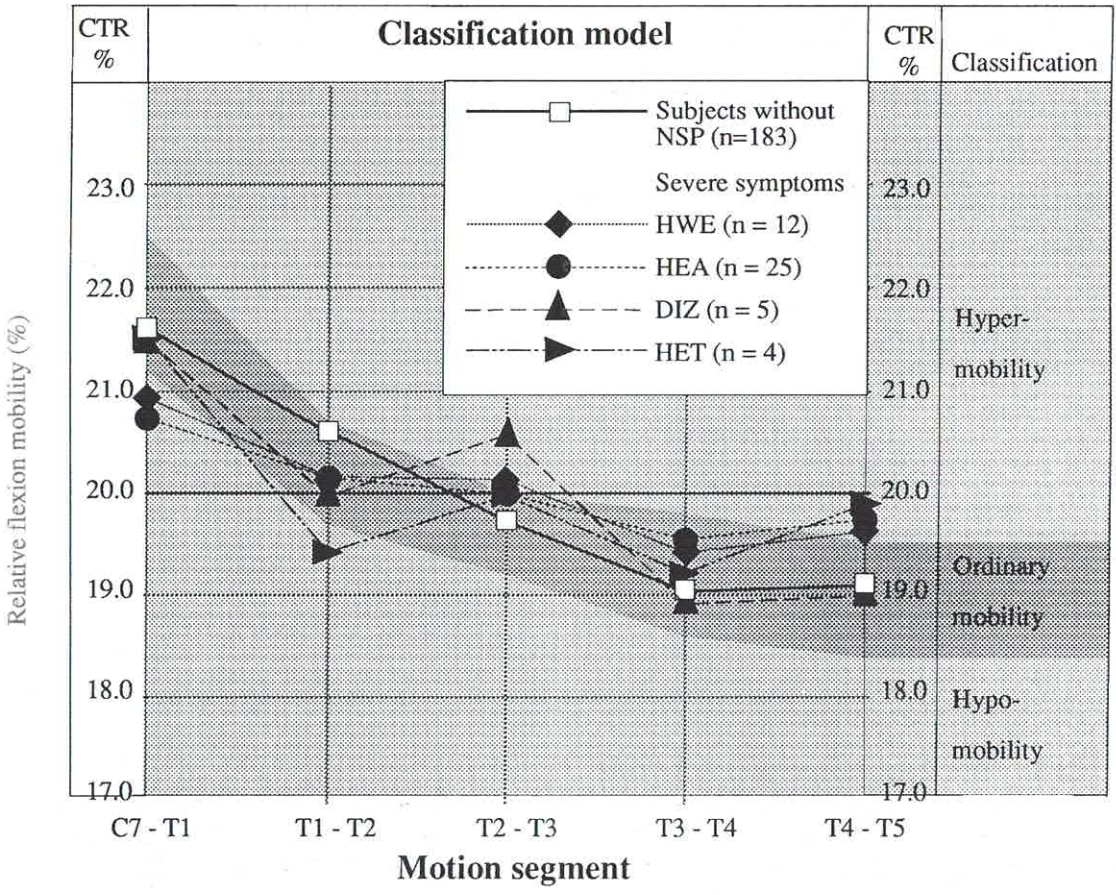

Fig. 1. Mobility profiles describing the distribution of cervico-thoracic ratio % mobility comparing subjects with neck-shoulder pain (NSP) and severe symptoms and subjects without. HWE = weakness in hands; HEA = headache; AGE = age; STR = mental stress; DIZ = dizziness; HET = pain in the region of the heart.

irrespective of mobility class at level C7–T1 and defined as, all C7–T1 mobility, and secondly for the different mobility classes, respectively, to determine whether the degree of C7–T1 mobility influenced the outcome of the predictors (Table I). All classifications were made with reference from level C7–T1.

2. In order to determine whether any of the NSPI predictors showed a relationship to mobility in any of the five motion segments C7–T1, T1–T2, T2–T3, T3–T4 and T4–T5, a new stepwise regression analysis was performed. Each predictor was analysed as dependent versus the five levels respectively including NSPI. An analysis was first done for all C7–T1 mobility and then for the different C7–T1 mobility classes (Table II).

3. The relative occurrence (12 months prevalence) of symptoms was compared between subjects with and without NSP. Odds ratios (20) were used and the standard rate ratio was applied by stratifying for the confounding variables age and mental stress. Age was stratified in age groups 18–45, 46–65 years, and mental stress in stress index scores 1–2.5 and 2.6–5.0 (Table III).

4. The distribution of mobility was compared between subjects with and without NSP and severe symptoms. Differences in distribution of mobility were tested by comparing mean CTR mobility and 95% confidence intervals between groups (Table IV, Fig. 1).

RESULTS

1. Predictors of NSPI and influence of C7–T1 mobility

For all C7–T1 mobility with complete answers ($n = 237$) the analysis showed that of the established set of eight independent variables, weakness in the hands, headache, age, and mental stress were the best predictors of NSPI (Table IA). Together, these variables explained 41%. For subjects with ordinary C7–T1 mobility ($n = 86$) the variables, weakness in the hands age and dizziness were the best predictors of NSPI (Table IB), together explaining 54%. For subjects with hypomobility C7–

Table I. *A stepwise regression analysis of the relationship between the dependent variable neck-shoulder pain index (NSPI) and the set of independent variables with a test of significance for inclusion of additional variables. Additional contribution for inclusion of a new variable is presented as r^2 values*

	Dependent variable NSPI		
Mobility classes C7–T1	Independent variable	Beta coeff.	r^2/Additional contribution for inclusion of variable
A. All mobility ($n = 237$)	HWE	0.45**	0.32**
	HEA	0.22**	0.04***
	AGE	0.20**	0.03***
	STR	0.11*	0.02***
B. Ordinary mobility ($n = 86$)	HWE	0.42**	0.40***
	AGE	0.31**	0.08***
	DIZ	0.29**	0.06***
C. Hypomobility ($n = 109$)	HWE	0.37**	0.24***
	HEA	0.20*	0.05**
	STR	0.22**	0.04*
	AGE	0.21**	0.05**
D. Hypermobility ($n = 42$)	HET	0.50**	0.35***
	DIZ	0.42**	0.16***
E. Inverse function ($n = 74$)	HWE	0.46**	0.42***
	STR	0.21**	0.05*
	AGE	0.24**	0.05**
	HEA	0.19**	0.03*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
HWE = weakness in hands; HEA = headache; AGE = age; STR = mental stress; DIZ = dizziness; HET = pain in the region of the heart.

T1 ($n = 109$) the variables, weakness in the hands, headache, mental stress and age were the best predictors of NSPI (Table IC), together explaining 38%. For subjects with hypermobility C7–T1 ($n = 42$) the variables, pain in the region of the heart and dizziness were significant predictors of NSPI (Table ID), together explaining 51%. For subjects with inverse C7–T1 function ($n = 74$) the variables, weakness in the hands, mental stress, age and headache were the best predictors of NSPI (Table IE), together explaining 55%.

To summarize the analyses, it was shown that C7–T1 mobility influenced the outcome of NSPI predictors. The strongest predictor was the symptom, weakness in the hands. Weakness in the hands ranked as the most significant predictor in all the regression models except for the hypermobility class, which showed a quite different setup of predictors. The variables paresthesia in the hands and number of working years were not ranked in any of the regression models as significant predictors of NSPI.

2. Variables showing a mobility-dependent relationship

NSPI. The following variables were evaluated versus segmental mobility in each of the five motion segments between C7 and T5; NSPI, weakness in the hands, headache, age, mental stress, dizziness and pain in the region of the heart. For NSPI the analysis of all C7–T1 mobility showed that increased mobility at levels T3–T4 and T4–T5 and decreased mobility at levels C7–T1 and T1–T2 were significant predictors of NSPI (Table IIA). For subjects with ordinary mobility at level C7–T1 ($n = 100$), decreased mobility at level T1–T2 was a significant predictor of NSPI (Table IIB). Among subjects classified as hypomobile at level C7–T1 ($n = 115$), increased mobility at level T3–T4 and decreased mobility at level C7–T1 were significant predictors of NSPI (Table IIC). Among subjects with inverse function at level C7–T1 ($n = 78$), decreased mobility at level T1–T2 was the strongest predictor of NSPI and explained 14% (Table IIE). Consequently, the study revealed that NSPI showed a mobility-dependent relationship to reduced mobility at both levels C7–T1 and T1–T2.

HWE. For the symptom HWE the stepwise regression analysis for all C7–T1 mobility ($n = 253$) showed that decreased mobility in motion segments C7–T1 and T1–T2 were significant predictors (Table IIA). For subjects with ordinary mobility at level C7–T1 ($n = 100$), decreased mobility at level T1–T2 was a significant

Table II. *A stepwise regression analysis of the relationship between dependent variables and relative mobility in motion segments between C7 and T5 as independent variables. Additional contribution for inclusion of a new variable is presented as r^2 values*

	Dependent variable	Independent variable	Beta coeff.	r^2/Additional contribution for inclusion of variable
A.	All C7–T1 mobility ($n = 253$)			
	NSPI	T4–T5	0.18**	0.04**
		T3–T4	0.13*	0.01
	NSPI[1]	C7–T1	−0.16**	0.03**
		T1–T2	−0.16**	0.02*
	HWE	C7–T1	−0.17**	0.03**
		T1–T2	−0.16**	0.03**
	HWE[1]	T4–T5	0.15*	0.02*
	HEA	C7–T1	−0.15*	0.02*
	AGE	T2–T3	−0.22**	0.03**
		T1–T2	−0.19**	0.03**
	STR	–	–	–
B.	Ordinary mobility C7–T1 ($n = 100$)			
	NSPI	T1–T2	−0.22*	0.05*
	HWE	T1–T2	−0.25**	0.06**
	AGE	–	–	–
	DIZ	T2–T3	0.31**	0.09**
C.	Hypomobility C7–T1 ($n = 115$)			
	NSPI	T3–T4	0.24**	0.05*
		T4–T5	0.16*	0.02
	NSPI[1]	C7–T1	−0.20*	0.03*
		T1–T2	−0.15*	0.02
	HWE	C7–T1	−0.29**	0.07**
		T1–T2	−0.17*	0.03
	HEA	T3–T4	0.19*	0.04*
	AGE	T2–T3	−0.21*	0.05*
	STR	–	–	–
D.	Hypermobility C7–T1 ($n = 48$)			
	NSPI	–	–	–
	HET	T4–T5	0.24*	0.06*
	DIZ	–	–	–
E.	Inverse function C7–T1 ($n = 74$)			
	NSPI	T1–T2	−0.37***	0.14***
	HWE	C7–T1	−0.24***	0.10***
		T1–T2	−0.23***	0.05*
	STR	–	–	–
	AGE	T2–T3	−0.23*	0.05*
	HEA	–	–	–

[1] Inclusion shows significant influence, but in opposite direction.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

HWE = weakness in hands; HEA = headache; AGE = age; STR = mental stress; DIZ = dizziness; HET = pain in the region of the heart.

Table III. *Odds ratio (OR) and 95% confidence intervals (CI 95%) comparing the experience of different symptoms in subjects with and without neck-shoulder pain, Standard rate ratio was applied (SRR) controlling for the two confounding variables age and mental stress*

		Neck-shoulder pain				
Symptom		Yes	No	OR	CI 95%	SRR
HWE ($n = 272$)	Yes	41	14			
	No	75	142	5.5	3.0–10.4	6.0
DIZ ($n = 275$)	Yes	37	25			
	No	81	132	2.4	1.4–4.3	2.3
HEA ($n = 274$)	Yes	78	63			
	No	40	93	2.9	1.8–4.7	3.0
HET ($n = 266$)	Yes	28	18			
	No	85	135	2.5	1.3–4.7	2.6

HWE = weakness in hands; HEA = headache; AGE = age; STR = mental stress; DIZ = dizziness; HET = pain in the region of the heart.

predictor of weakness in the hands (Table IIB). Among subjects classified as hypomobile at level C7–T1 ($n = 115$), decreased mobility at level C7–T1 was a significant predictor of HWE (Table IIC). Among subjects with inverse function at level C7–T1 ($n = 78$), decreased mobility at levels C7–T1 and T1–T2 was the strongest predictor of weakness in the hands and together explained 15% of weakness in the hands (Table IIE). Consequently, it was found that the symptom weakness in the hands showed a mobility-dependent relationship to reduced mobility at both levels C7–T1 and T1–T2 in the same fashion as NSPI (Table IIE).

Symptoms HEA, DIZ, HET and factors AGE, STR. For the symptom headache, the analysis of mobility showed that decreased mobility in motion segments C7–T1 and T3–T4 was a significant predictor of HEA (Tables IIA, C). For the factor age the analysis of mobility showed that decreased mobility levels in motion segments T2–T3 and T1–T2 were significant predictors of age (Table IIA, C, E). The factor mental stress was not influenced significantly by segmental mobility between C7 and T5 (Table IIA, C, E). For the symptom dizziness, the analysis showed that increased mobility at level T2–T3 was a significant predictor of dizziness (Table IIB). For the symptom pain in the region of the heart, the analysis for subjects with hypermobility at level C7–T1 ($n = 48$) showed no significant relationship (Table IID). To summarize the stepwise regression, the analysis showed that in motion segments C7–T1 and T1–T2 reduced mobility was the strongest predictor of the variables NSPI and weakness in the hands. The highest degree of explanation was found for the symptom weakness in the hands with 15% and for NSPI with 14% (Table IIE), both among subjects classified as inverse C7–T1 function.

3. *Occurrence of NSP related symptoms*

The 12 months' prevalence rates of the symptoms weakness in the hands, dizziness, headache and pain in the region of the heart in the total study group ($n = 281$) were 20%, 22%, 50%, and 16%, respectively. The analysis showed that the experience of all these symptoms was significantly related to the experience of NSP (Table III). After controlling for the confounding variables mental stress and age, the standardized rate ratio was 6.0 for the symptom weakness in the hands, 2.3 for the symptom dizziness, 3.0 for the symptom headache and 2.6 for the symptom pain in the region of the heart (Table III).

4. *Distribution of segmental mobility*

A comparison between the mean values for subjects with NSP and severe symptoms and the 95% confidence limits for subjects without NSP showed that subjects with severe weakness in the hands and headache had a significantly decreased mobility in motion segments C7–T1 compared with subjects without NSP (Table IV, Fig. 1).

Subjects with severe dizziness and pain in the region of the heart showed an equal degree of mobility at level C7–T1 as did subjects without NSP (Table IV, Fig. 1). Yet at level T1–T2, mobility was significantly decreased for all severe symptoms and at level T2–T3 significantly

Table IV. *Cervico-thoracic ratio % values for each motion segment, describing the differences in distribution of relative mobility between subjects with and without neck-shoulder pain (NSP) and severe symptoms, weakness in the hands (HWE), headache (HEA), dizziness (DIZ) and pain in the region of the heart (HET)*

	Subjects without NSP (n = 183)			Subjects with NSP and severe symptoms							
				HWE (n = 12)		HEA (n = 25)		DIZ (n = 5)		HET (n = 4)	
Motion segment	CTR % $\bar{X}$	SD	CI 95%	CTR % $\bar{X}$	SD	CTR % $\bar{X}$	SD	CTR % $\bar{X}$	SD	CTR % $\bar{X}$	SD
C7–T1	21.6	1.3	(21.4–21.7)	20.9*	1.4	20.7*	1.0	21.5	1.2	21.5	1.4
T1–T2	20.6	1.0	(20.5–20.8)	20.1*	0.8	20.1*	0.8	20.0*	0.7	19.4*	0.7
T2–T3	19.7	1.1	(19.5–19.8)	20.1*	0.7	20.0*	0.7	20.6*	1.2	20.0*	1.2
T3–T4	19.0	1.0	(18.9–19.2)	19.4*	0.7	19.5*	0.8	18.8	0.3	19.2	1.2
T4–T5	19.1	1.0	(19.0–19.2)	19.6*	0.7	19.7*	0.7	19.0	0.8	19.9*	1.2

increased compared with subjects without NSP (Table IV, Fig. 1). Consequently, subjects with NSP and severe symptoms of weakness in the hands, headache, dizziness or pain in the region of the heart showed deviation from the synchronous distribution of mobility in adjacent motion segments. The mobility profile (Fig. 1) showed both increases and decreases compared to the rather smooth and synchronous distribution in subjects without NSP.

DISCUSSION

This study has shown that out of the eight independent variables used to select the best predictors of musculoskeletal neck-shoulder pain, six variables were included in the different models (Table I). When analysed for all C7–T1 mobility levels the significant variables were, weakness in the hands, headache, age and mental stress, (Table IA). When the analysis was carried out for the different C7–T1 mobility classes the outcome of predictors partly changed (Tables IB–E). Among subjects classified as ordinary or hypermobile at level C7–T1 the two variables dizziness and pain in the region of the heart were included in the models as significant predictors of NSPI (Tables IB, D), whereas the variables headache, weakness in the hands and mental stress were excluded (Tables IB, D). Reduced mobility at level C7–T1 as in the groups with hypomobility or inverse function showed an identical setup of predictors to those for all C7–T1 mobility levels (Tables IA, C, E).

The variables included in the different models provide, at least partly, a quite high degree of explanation of NSPI. They have previously been recognized as related to NSP (2–6, 12–13, 16–17, 23–25). Consequently, the risk of inclusion of false positives in the models was rather low. The analysis, however, showed that the outcome of the predictors was dependent on the degree of C7–T1 mobility. Thus the experience of a symptom may depend on and may be influenced by segmental mobility. Consequently, segmental mobility may be one of the possible underlying causes provoking the different symptoms.

The stepwise regression analysis showed that several symptoms including NSPI were mobility-dependent, not only in level C7–T1 (Table II). Level C7–T1 was merely used as reference for classification in order to systematize the different analyses (Table II).

Analyses of all C7–T1 mobility levels did not provide such a high degree of explanation between different symptoms and segmental mobility (Table IIA) as when the analysis was performed for the different mobility classes (Table IIB, C, E). For the variable NSPI, reduced segmental mobility at levels C7–T1 and T1–T2 together explained 5% of NSPI analysed for all C7–T1 mobility (Table IIA), but the inclusion of only those subjects classified as having an inverse C7–T1 function improved the degree of explanation to 14% (Table IIE). This could be interpreted as an indication that motion segments are involved in distinct combinations of mobility, and if increased and decreased mobility levels are not separated at the segmental level, an analysis will result in the conclusion that mobility is a factor of less significance.

The group classified as having an inverse C7–T1 function is of special interest in the assessment of musculoskeletal neck-shoulder pain. This study has

shown stronger relationships to several of the studied variables compared to the other mobility classes (Tables I, IIE). Inverse C7–T1 function has previously been shown to predict NSP (24), and obviously mobility in motion segments C7–T1 and T1–T2 is a factor of significant importance in musculoskeletal neck-shoulder pain. We are, however, also aware of the fact that the motion segments above C7 might also be involved in NSP (5). Nevertheless, a contribution of 14% to the explanation of NSPI dependent on reduced mobility at level T1–T2 among subjects with inverse C7–T1 function is obvious (Table IIE). Accordingly, the relationship between weakness in the hands and reduced mobility at levels C7–T1 and T1–T2 emphasizes the importance of these articulations. Together, mobility explained 15% of weakness in the hands among subjects classified as having an inverse C7–T1 function (Table IIE). Of all the studied symptoms, the sensation of weakness in the hands was the one most strongly related to NSPI. Standard rate ratio was 6.0 (Table III).

Motion segments C7–T1 and T1–T2 correspond to the spinal levels where the roots of the ulnar nerve and parts of the median nerves originate. Both nerves supply the flexor muscles of the forearm and the hand. Consequently, the sensation of weakness in the hands is a reasonable symptom from a neurological point of view. Weakness in the hands was, however, only subjectively reported and not objectively measured. The clinical value of such information from the patient ought to be further evaluated. Measurement of the grip strength should be included. Recently, however, several experimental studies report that joint structures, such as capsules and ligaments, have an important role as providers of sensory feedback to the CNS and are not just passive structures with the mechanical function of keeping joints together (8–11). Thus, the symptom weakness in the hands may, according to our interpretation, possibly be an experience of sensory feedback from joint afferents due to the joint dysfunction at levels C7–T1 and T1–T2 and not necessarily to an objectively reduced grip strength in connection with nerve root compression.

Subjects who experienced severe symptoms of weakness in the hands, headache, dizziness and pain in the region of the heart along with NSP showed significantly reduced mean relative segmental mobility at level T1–T2 and significantly increased mean relative segmental mobility at level T2–T3 compared with subjects without NSP (Table IV, Fig. 1). This kind of non-synchronous distribution of mobility, including increases and decreases between adjacent motion segments, compared to the rather smooth and synchronous distribution seen for subjects without NSP (Fig. 1), might in our estimation be a factor provoking sensitive receptors in joint structures. Sensitive joint receptors might influence the regulation of muscle stiffness (11).

The prevalence of headache was significantly related to NSPI and the standard rate ratio was 3.0 (Tables IA, C, E, III). Reduced segmental mobility was a significant predictor of headache (Table IIA, C). If segmental dysfunction increases muscle stiffness in the cervicothoracic erector muscles, it might influence the upper cervical spine and thereby be a component in the experience of cervicogenic headache as described by Bogduk (4).

The sensation of dizziness was significantly related to NSPI and the standard rate ratio was 2.3 (Tables IB, D, III). Increased segmental mobility at level T2–T3 was significantly related to dizziness (Table IIB). According to the interpretation of the dynamics in the CTR concept such an increase might, at least partly, be a consequence of reduced mobility at the T1–T2 level as seen among subjects with severe dizziness (Table IV). In the same way, segmental dysfunction may be a component resulting in experience of dizziness, as suggested by Norré (25). Several studies have shown that disturbances in tendons, joints and ligaments in the cervical spine can provoke dizziness (3, 12, 13, 16).

The experience of pain in the region of the heart was the strongest predictor of NSPI among subjects with hypermobility at level C7–T1 (Table ID). There was, however, no evidence of a relationship between pain in the region of the heart and segmental mobility in the regression analysis (Table IID). However, the experience of pain in the region of the heart was significantly related to NSPI, standard rate ratio 2.6 (Tables ID, III). In subjects with experience of severe pain in the region of the heart, there was a significantly reduced segmental mobility at level T1–T2 (Table IV, Fig. 1).

Mental stress was a significant predictor of NSPI (Tables IA, C, E). It did not, however, relate to segmental mobility between C7 and T5.

The factor age was a significant predictor of NSPI (Tables IA, B, C, E) and was also mobility-dependent (Tables IIA, C, E). Our interpretation of the relationships between age, disorder and mobility is that an absolute decrease in mobility in all motion segments as seen in older age with a synchronous distribution between motion segments is not the issue. The problem arises when the mobility shows deviation from synchronous

distribution, as this might provoke sensitive receptors in different joint structures as previously suggested.

CONCLUSION

The strongest predictor of neck-shoulder pain was the symptom weakness in the hands.

Weakness in the hands and neck-shoulder pain showed a significant correlation with reduced segmental flexion mobility at levels C7–T1 and T1–T2.

The symptoms weakness in the hands, headache and dizziness showed a significant correlation with segmental mobility in the upper cervico-thoracic motion segments.

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Address for offprints:

Staffan Norlander
Byggbranschens Forskningsstiftelse för Arbetsmiljö
Kungsgatan 66, 4 tr
SE-111 22 Stockholm
Sweden