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REDUCED MOBILITY IN THE CERVICO-THORACIC MOTION SEGMENT—A RISK FACTOR FOR MUSCULOSKELETAL NECK-SHOULDER PAIN: A TWO-YEAR PROSPECTIVE FOLLOW-UP STUDY

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ABSTRACT. **The aim of this study was to evaluate the variations in C7–T1 mobility in order to decide whether inverse C7–T1 function, defined as equal or less mobility in motion segment C7–T1 compared with T1–T2, could be used for prediction of neck-shoulder pain (NSP). One hundred and sixty-one female laundry workers participated in a prospective two-year follow-up study which included a self-report questionnaire and clinical examinations. The present study showed that the incidence of inverse C7–T1 function was 33% per year and subjects classified as having an inverse C7–T1 function three or more times during the follow-up period had an elevated risk of NSP (RR 3.1, CI 95% 1.1–6.9). According to the authors' interpretation, lack of synchronous mobility distribution between adjacent motion segments might be a provoking factor. Inverse C7–T1 function predicts NSP related to the cervico-thoracic articulations and yields a positive predictive value of 84%. Assessments must be repeated, however.**

Key words: C7–T1 mobility, neck-shoulder pain, predictive value.

INTRODUCTION

Many conditions are connected with pain in the neck and shoulders and other sensations of discomfort in the upper extremities. The pathophysiological mechanism resulting in unspecified work-related neck-shoulder pain (NSP) is not clearly understood and different symptom diagnoses are used to describe these conditions. The term cervico-brachial pain syndrome is often used and in the following is synonymous with NSP. According to Harms-Ringdahl et al. (5) cervico-brachial pain may be provoked by mechanical load on passive spinal connective structures. The cervico-thoracic articulations are one of three sites in the cervical spine that are exposed to major stress, as are the occipital-atlas-axis region and the site of the maximum lordosis (3). Several studies have recognized relationships between function in the cervico-thoracic articulations and NSP. In a study of prolonged extreme flexion position of the cervico-thoracic articulations it was shown that healthy subjects perceived pain in a region mainly corresponding to the C7–T1 level during provocation by extreme flexion position (5). In a study of thoracic outlet syndrome, dysfunctions at level C7–T1 were suggested as a mechanism provoking cervico-brachial pain (9). Norlander et al. (13, 14) reported that hypomobility at level C7–T1 was an indicative factor of NSP. According to Yabuki & Kiiuchi (16) special attention should be paid to the C7 level as the occurrence of proximal dorsal root ganglion was more frequent among patients with C7 cervical radiculopathy. The significance of joint mobility as an important factor in musculoskeletal disorders has also been described by Johansson & Sojka (6). Consequently, further research is important in order to understand the role of the cervico-thoracic articulations in NSP.

In clinical practice segmental mobility has been difficult to measure and assess as there has been a lack of methods to measure mobility in a specific motion segment. However, Norlander et al. (11–14) used a new method in their studies of relationships between NSP and segmental mobility defined as the Cervico-Thoracic Ratio (CTR). The method focuses on the function of the cervico-thoracic articulations between C7 and T5 and mobility can be classified in a concept of relative mobility distribution defined as ordinary, hyper- and hypomobility, respectively, for each of the motion segments. As healthy subjects have been used in order to develop the concept, none of the three classes are regarded as having "pathological" mobility even though NSP has been found to be more frequent among subjects

with hypomobility at level C7–T1 compared with subjects with ordinary and hypermobility.

A specific sequence of mobility involving both C7–T1 and T1–T2 is the inverse C7–T1 function. The inverse C7–T1 function has been defined as having greater or equal flexion mobility at level T1–T2 compared with level C7–T1 (13). This is a clear deviation from the normal distribution of mobility in this region (1). The inverse C7–T1 function has also shown a significant relationship to both NSP and other subjectively experienced symptoms (13, 14). The occurrence of the inverse C7–T1 function is approximately 30% in a mixed female and male population (13).

As level C7–T1 often may be involved in NSP, the aim of this study was to evaluate the normal variation in C7–T1 mobility in a group of female laundry workers in a two-year prospective follow-up study, in order to analyse whether the inverse C7–T1 function could be used as a diagnostic criterion in health assessments for the prediction of NSP.

MATERIALS AND METHODS

Study design

A total of 161 female laundry workers participated in a two-year prospective follow-up study. All subjects answered the standardized Nordic questionnaire (8) about musculoskeletal complaints. A physiotherapist examined their mobility in a single-blind design according to the CTR technique. Examinations were repeated every six months, new subjects were added during the first year. Subjects had to participate at least three times, including the last examination after 24 months (Fig. 1).

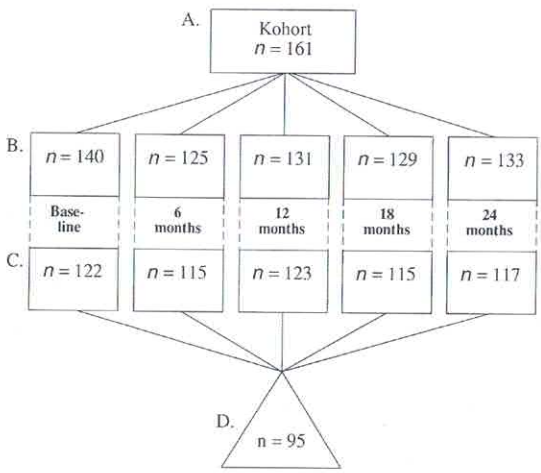

Fig. 1. Schedule over number of subjects participating in the two-year follow-up study. A. Total number of subjects participating. B. Number of subjects participating in each examination. C. Number of subjects of B participating in three or more examinations. D. Number of subjects participating in all five examinations.

Table I. *Data for all subjects in group C defined as cases or controls, respectively, in NSI (n = 130)*

Background variables	Neck-shoulder index Cases ($n = 68$) $\bar{x}$	SD	Controls ($n = 62$) $\bar{x}$	SD
Age (years)	43.9	10.3	38.3*	12.1
Weight (kg)	64.3	9.9	62.0	11.5
Height (cm)	163.2	6.3	162.6	6.4
BMI	24.2	3.4	23.4	4.3
Working years	11.6	6.8	8.2*	7.5

*$= p < 0.05$.

Definition of neck-shoulder pain

Three different indices were used; neck index (NI), shoulder index (SI) and neck-shoulder index (NI+SI) / 2=(NSI). The questions for NI and SI were "For how long during the previous 12 months have you had pain in the neck and/or the shoulders?", respectively. The answers for NI and SI were divided into five different categories; 1=0 days, 2=1–7 days, 3=8–30 days, 4=>30 days (but not daily), 5=daily. Subjects answering NI and/or SI of more than seven days were defined as cases. Subjects answering both NI and SI equal to or of less than seven days were defined as controls. The somewhat more manifest period of 8–30 days was chosen as the definition of NSP, as a very short period of 1–7 days could 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 with segmental mobility, which may support our point of view (13). There was a significant difference between cases and controls (Table I) for the background variable number of working years.

Measuring of mobility

The CTR technique has been developed in order to measure the relative segmental flexion mobility in the cervico-thoracic motion segment and the upper thoracic spine, 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 and 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 (7).

Absolute flexion mobility is defined as the measured changes in millimetres (mm), 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. (11), as well as its validity and repeatability (12).

Classification model for mobility

The classification model for relative flexion mobility (11) was created so that the class ordinary mobility 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 (11). The hyper- and hypomobility classes each comprised 25% of the mixed healthy population. Thus, none of the three classes have been defined as "pathological segmental mobility" as they are all defined from a healthy population.

In motion segment C7–T1 the limits for relative flexion mobility for the ordinary mobility class range 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 relative flexion mobility less than 21.2%. The ordinary CTR% limits for motion segments C7–T5 are shown in the shaded area (Fig. 3). The horizontal line at CTR 20% constitutes the starting-point for equal relations between all five motion segments C7–T5 (Fig. 3).

Statistical analysis

As the inverse C7–T1 function was chosen as the sole diagnostic criterion, the individual variations in C7–T1 mobility were evaluated by counting the number of times a subject was classified as having an inverse C7–T1 function at the five examinations performed every six months. In order to study changes in the distribution of mobility, the mean CTR% values were evaluated for each motion segment with the paired *t*-test. Differences in standard deviations were also evaluated for each motion segment with the F-test. Individual background variables were evaluated by analysis of variance (ANOVA).

The relative risk (RR) of incidence of NSP and the 95% confidence interval were calculated according to Miettinen (10) and analysed for groups C and D (Fig. 1). The risk estimation was calculated as the outcome at 24 months. It compared the total number of cases and controls, respectively, in the two groups; variable C7–T1 function (VF = negative test), and invariable C7–T1 function (IF = positive test). VF was defined as an inverse C7–T1 function occurring two times or less. IF was defined as an inverse C7–T1 function occurring three times or more (Fig. 2) during the two-year follow-up period.

The sensitivity was calculated as the proportion of cases classified as IF (positive) out of the total number of cases, and the specificity as the proportion of controls classified as VF (negative) out of the total number of controls, after 24 months. Sensitivity and specificity were calculated on the basis of the distribution in group D. A highly sensitive test yields few false negatives, and a highly specific test is one with few false positives (4). The positive predicted value was calculated as the proportion of true positives compared with the total positive outcome, and the negative predictive value was calculated as the proportion of true negatives compared with the total negative outcome of the test (4).

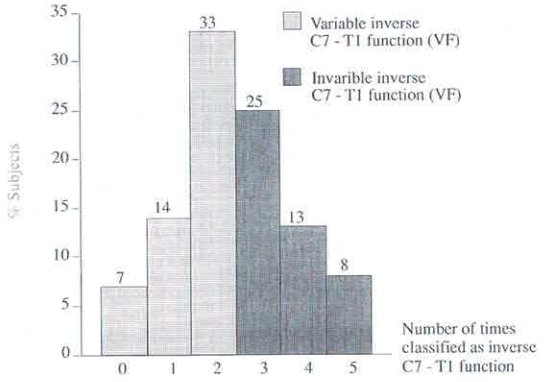

Fig. 2. Number of times subjects in group D have been classified as having an inverse C7–T1 function ($n = 95$).

RESULTS

Variation in C7–T1 mobility

The individual variations in C7–T1 mobility were evaluated by counting the number of times a subject was classified as having an inverse C7–T1 function. Variable C7–T1 function, VF (negative) was found in 54% of the subjects ($n = 51$) (Fig. 2) evaluated for group D. Invariable C7–T1 function IF (positive) was found in 46% ($n = 44$) (Fig. 2). There was a significant difference between subjects in the VF and IF groups for the background variable age (Table II). The distribution of number of times a subject was classified as having inverse C7–T1 function during the two-year follow-up period was fairly normally distributed (Fig. 2). Obviously C7–T1 mobility was variable over time, and changed between the different classifications of C7–T1 mobility described in the concept of classification. Mobility was more variable in the younger VF group compared with in the six-years' older IF group (Table II).

Change in the distribution of segmental mobility

A further analysis of C7–T1 mobility revealed that in the IF group, there was a gradual change in relative mobility between motion segments C7–T1 and T1–T2 during the two-year follow-up period (Table III, Fig. 3). At base line, mean CTR mobility in motion segment C7–T1 was 20.8% and classified as hypomobile according to the relative CTR concept, but the function was not inverse (Table III, Fig. 3). After 12 and 24 months, respectively,

Table II. *Data for all subjects in group C defined as having an invariable or variable inverse C7–T1 function, respectively* ($n = 130$)

Background variables	C7–T1 function Invariable-IF ($n = 54$) $\bar{x}$	SD	Variable-VF ($n = 76$) $\bar{x}$	SD
Age (years)	44.9	11.6	38.6*	10.8
Weight (kg)	64.3	10.2	62.6	11.0
Height (cm)	163.0	6.3	162.9	6.4
BMI	24.1	3.7	23.6	4.0
Working years	11.1	7.4	9.2	7.3

* $= p < 0.05$.

Table III. *Changes in mean relative flexion mobility (CTR%) during the two-year follow-up period for the group classified as having invariable C7–T1 function (IF) (n = 44)*

Motion segment	Baseline CTR%	SD	12 months CTR%	SD	24 months CTR%	SD
C7–T1	20.8	0.9	20.4*	0.7	20.2**	0.8
T1–T2	20.3	0.9	20.7*	0.8	20.6(*)	0.7
T2–T3	19.8	0.7	20.0	0.6	19.9	1.1
T3–T4	19.5	0.8	19.6	0.7	19.6	1.0
T4–T5	19.5	0.8	19.4	0.9	19.6	1.8

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

C7–T1 mobility had decreased significantly to 20.4% and 20.2% (Table III, Fig. 3).

The T1–T2 mobility had increased significantly from 20.3% at baseline to 20.7% at 12 months. At 24 months, mobility was 20.6% significant at level $p < 0.1$ and tangential to being classified as relative hypermobility in motion segment T1–T2 according to the CTR concept (Table III, Fig. 3). Inverse C7–T1 function had been developed and there was a lack of synchronous mobility distribution between the two adjacent motion segments C7–T1 and T1–T2.

To analyse the dynamics of the relative CTR concept it may be beneficial to clarify that the degree of increase in mobility at level T1–T2 is a direct consequence of the reduction in mobility at level C7–T1 if all other levels are constant. Therefore the increase is not necessarily absolute. The CTR concept merely indicates that mobility between adjacent motion segments is not synchronous.

In the group with VF there was no significant change in motion segment C7–T1 (Table IV, Fig. 4). At baseline, mean CTR mobility was classified as ordinary at 21.3%. After 24 months C7–T1 mobility had decreased slightly to 21.2% , but tangential to the limit of being classified as hypomobile according to the CTR concept (Table IV, Fig. 4).

For motion segment T1–T2, mean CTR mobility had increased from 20.2% at baseline to 20.6% and 20.5% at 12 and 24 months, respectively, but was still not classified as inverse C7–T1 function. In relative values the increase at level T1–T2 was greater than the reduction in

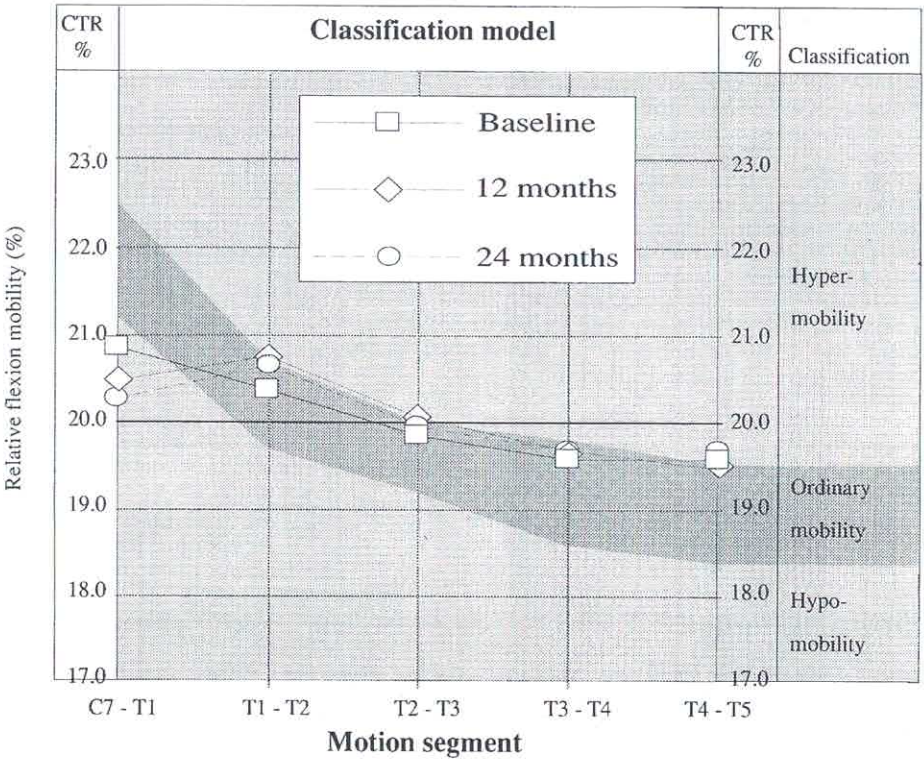

Fig. 3. Mobility profile describing the changes in distribution of mobility for motion segments C7 to T5, according to the CTR technique, during the two-year follow-up period for the group classified as having invariable C7–T1 function (IF) ($n = 44$).

Table IV. *Changes in mean relative flexion mobility (CTR%) during the two-year follow-up period for the group classified as having variable C7–T1 function (VF) (n = 51)*

Motion segment	Baseline CTR%	SD	12 months CTR%	SD	24 months CTR%	SD
C7–T1	21.3	1.1	21.2	1.2	21.2	1.0
T1–T2	20.2	1.1	20.6*	0.8	20.5	0.7
T2–T3	19.4	1.2	19.7	0.7	19.8	1.6
T3–T4	19.5	0.8	19.4	0.8	19.2	1.2
T4–T5	19.6	1.0	19.1**	1.1	19.4	2.5

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

mobility at level C7–T1. Therefore the increase is a consequence of an absolute increase. This is in accordance with the interpretation of the CTR dynamics. The increase was significant after 12 months, but not at 24 months. Obviously mobility was variable, showing changes in the relative distribution (Table IV). In motion segment T4-T5 there was a significant decrease at 12 months (Table IV).

Standard deviation (SD) was significantly ($p < 0.05$) less in all motion segments except T1–T2 in the IF group compared with the VF group at 24 months (Tables III–IV). Consequently, not only level C7–T1 was less variable, also the three levels below T1–T2 showed less variation in mobility in the IF group. Level T1–T2, however, showed the same magnitude of standard deviation in both groups.

Invariable C7–T1 function—a risk factor for musculoskeletal neck-shoulder pain

A comparison of number of cases and controls between subjects with VF and IF revealed that in both group C and D the relative risks (RR) were increased. RR was 2.7 and 3.1, respectively, for subjects in IF to have had a period of more than one week of NSP during the 24-month follow-up period, compared with subjects in VF (Table V). Consequently, a variable C7–T1 function was important in order not to develop NSP. In group C, 84% (117/140) of subjects fulfilled the criteria for inclusion and in group D 68% (95/140) compared to baseline. As a result, the number of dropouts was kept down and the study groups accordingly were sufficiently representative.

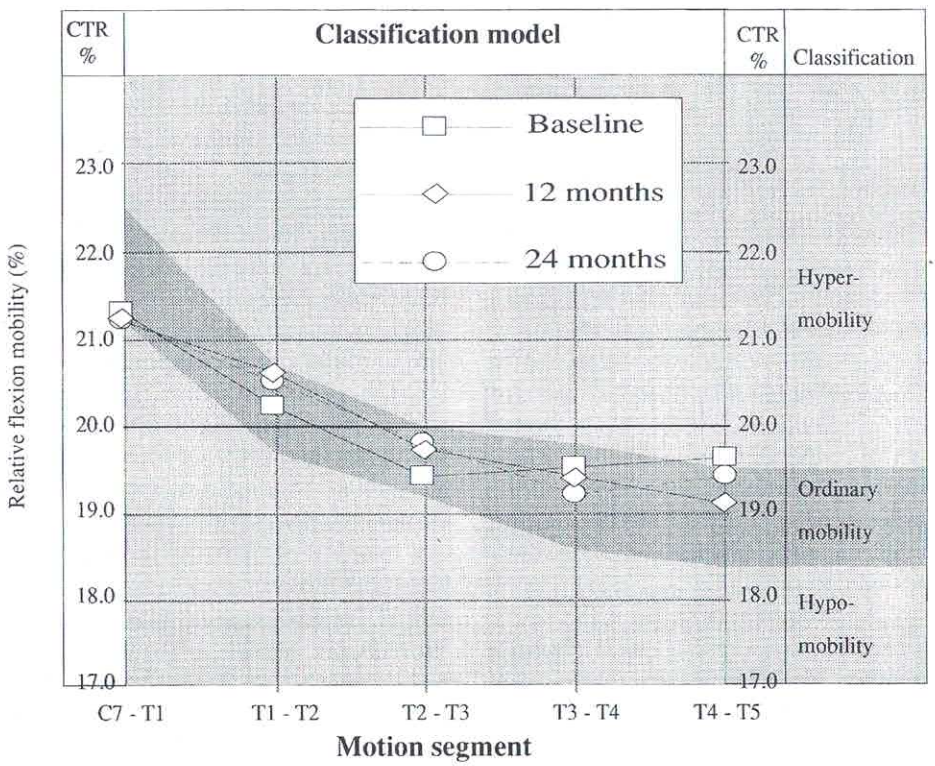

Fig. 4. Mobility profile describing the changes in distribution of mobility for motion segments C7 to T5, according to the CTR technique, during the two year follow-up period for the group classified as having variable C7–T1 function (VF) ($n = 51$).

Table V. *Relative risk of developing neck-shoulder pain for a period of more than one week during the two-year follow-up period for group C (n = 117) and group D (n = 95)*

Group	Subjects	Inverse C7–T1 function Invariable (IF)	Variable (VF)	Relative risk (RR)	Confidence interval (CI 95%)
C.	Case	44	46	2.7*	1.1–6.9
	Control	7	20		
D.	Case	37	32	3.1*	1.2–8.3
	Control	7	19		

* Incidence of neck-shoulder pain for more than one week.

C7–T1 function—as a predictor of musculoskeletal neck-shoulder pain

The sensitivity of the method was evaluated for group D ($n = 95$) participating in all five examinations. The sensitivity defining IF as positive resulted in a sensitivity of 54%, 37 true positives out of 69. The specificity defining VF as negative was 73%, 19 true negatives out of 26. The positive predictive value after the two-year follow-up period was 84%, 37 true positives out of 44 classified as positives. The negative predictive value was 37%, 19 true negatives out of 51 classified as negatives.

In the first examination at baseline, 27% of the subjects were classified as having an inverse C7–T1 function. At 24 months 97% were classified as having an inverse C7–T1 function at least once. Thus, each year, 33% of the subjects have added a new classification to their previous one. Eventually the number of classifications will amount to three times their original number, which represents a threefold significantly increased risk of NSP.

DISCUSSION

The present study showed the normal variation in C7–T1 mobility and the changes in segmental mobility distribution during the two-year follow-up period. It was shown that the diagnostic criterion inverse C7–T1 function was fairly normally distributed from subjects never classified as having inverse C7–T1 function (Fig. 2), to subjects always classified as having inverse C7–T1 function. One interpretation of this study could thus be that a variation in C7–T1 mobility should be looked upon as a "normal phenomenon" in healthy subjects.

The degree and the variation in C7–T1 mobility can be influenced by several factors such as, for instance, posture influenced by familial-hereditary factors (3), disease, age or factors such as work posture, workload, physical exercise and mental stress. The analysis of C7–T1 mobility revealed two groups, group VF with a more mobile and a more variable C7–T1 mobility (Figs. 2, 4), as compared with group IF with less C7–T1 mobility and also a more invariable C7–T1 function (Figs. 2, 3). In the IF group it was shown that mean CTR% values of C7–T1 mobility gradually changed during the two-year follow-up period, from a normal sequence of relative flexion mobility towards a reduced mobility and inverse function at level C7–T1 (Table III, Fig. 3). This is a typical mobility profile for subjects with NSP, as previously described by Norlander et al. (13).

From a biomechanical point of view it is interesting to discover that this gradual change in mobility, as observed in the IF group, is located at the site of the lower major bulk of extensor musculature in the cervico-thoracic spine, which is one of the parts exposed to major stress and probably influenced by poor posture (3). This kind of non-synchronous distribution of relative mobility as seen in the IF group, including a rather sharp relative decrease and increase between the adjacent motion segments C7–T1 and T1–T2 (Fig. 3), compared with the rather smooth and synchronous distribution seen for subjects in the VF group (Fig. 4), might, according to our assumption, be a factor provoking mechano-sensitive receptors in joint structures. Mechano-sensitive receptors may increase muscle stiffness (6). Such an increase in segmental-related muscle stiffness may be a factor disturbing the normal sagittal flexion mobility together with the influence of poor posture. According to a previous analysis of the relationship between absolute and relative mobility for level C7–T1, a significant relationship was found corresponding to a degree of explanation between relative and absolute mobility equivalent to 73% (11). Consequently, the reduction in relative flexion mobility at level C7–T1 might also relate to a reduction in absolute flexion mobility.

In this study the T1–T2 motion segment showed increased relative mobility (Figs. 3–4). A previous analysis of the relationship between absolute and relative

mobility for level T1–T2 revealed a significant relationship corresponding to a degree of explanation between relative and absolute mobility equivalent to 47%. This indicates that motion segment T1–T2 is also influenced by mobility at level C7–T1, all according to the calculation and interpretation of the CTR concept (11). However, it has been shown that an inverse function with reduced relative mobility at level T1–T2 is a stronger predictor of NSP compared with an inverse C7–T1 function with increased relative mobility at level T1–T2 (14). Therefore at a later stage of NSP, segmental-related muscle stiffness could probably spread and also include a reduction in mobility at level T1–T2. The spread of muscle stiffness is a well-known pattern in musculoskeletal disorders (6). The fact that there were significantly fewer standard deviations in all motion segments except T1–T2 for the IF group compared to the VF group may support such an interpretation (Tables III–IV).

The change in the distribution of mobility may also at least partly be a consequence of age, as subjects in the IF group were significantly older than subjects in the VF group (Table II). The VF group showed a tendency that may be interpreted as an early sign in the development of inverse C7–T1 function (Table IV, Fig. 4). There was a significant increase in mean CTR% mobility in motion segment T1–T2 at 12 months. According to the interpretation of the CTR dynamics, this increase at level T1–T2 cannot be influenced solely by the reduction in mobility at level C7–T1, as the reduction was smaller than the increase at level T1–T2. Probably the inverse function is an alteration that develops gradually and includes both an increase in mobility at level T1–T2 and a possible decrease at level C7–T1, as seen in the IF group (Fig. 3). It is important to understand that the CTR concept describes changes in the synchronous distribution of relative mobility and not "absolute pathological hyper- or hypomobility". The fundamental aim of the CTR concept is to discover lack of synchronous distribution, displayed as obvious increases or decreases between adjacent motion segments, as according to our interpretation this may provoke NSP.

The comparison of the incidence of NSP between IF and VF revealed that subjects in the IF group had an elevated relative risk of having a period of more than one week of NSP during the two-year follow-up period compared with the VF group. The relative risk of incidence of NSP was 2.7 for group C and 3.1 for group D (Table V). The elevation of the risk showed approximately the same magnitude as described in a previous cross-sectional study (13). The study design including new subjects during the first year was beneficial as the number of dropouts compared to baseline was kept in check. In group C 84% fulfilled the criteria for inclusion and in group D 68% compared to baseline. In our estimation, the studied groups are sufficiently representative for females in industrial work and the criterion inverse function was found to be normally distributed. Thus we consider that conclusions concerning NSP and mobility at level C1-T1 are sufficiently valid.

The question is, however, whether age is the only factor increasing the occurrence of NSP or whether workload is just as important. In this study the working environment was very similar for all subjects as they worked in a typical environment shared by many female industrial workers. This included repetitive arm movements, static muscle tension on the neck–shoulders and low control on work performance. The definition of NSP in this study defined as "cases" showed that cases had a significantly greater number of working years compared with controls. This indicates that workload is also an important factor (Table III). The most likely interpretations of these results suggest that both factors are of importance for the development of NSP. In younger age, however, inverse C7–T1 functions tend to be more infrequent as mobility is more variable, resulting in a lower incidence of NSP as seen in the VF group (Table V). After a greater number of working years and increasing age, C7–T1 mobility becomes more invariable and results in greater occurrence of NSP as seen in the IF group (Table V).

The results of this study showed that invariable inverse C7–T1 function can predict NSP to some extent. An absolute condition, however, was that measures of the CTR profile had to be repeated in order to decide whether the inverse C7–T1 function was occasional or more permanent. According to this study the risk of developing NSP increased significantly when inverse function was recognized three or more times during the follow-up period. This indicates a gradual change, which makes it difficult to decide when preventive measures should be introduced. The sensitivity based on the two-year follow-up period was calculated to 54%. Consequently, the definition of negative subjects yields several false negatives. The specificity was calculated to 73%, which showed that the definition of positive subjects was more correct. In fact the positive predictive value was 84%, 37 true positives out of 44 classified as positives. In all probability the definition of negatives in this study resulted in a falsely lowered sensitivity, as

the diagnostic criterion for positive was being classified as having inverse C7–T1 function three times or more. Some of the reported cases in the VF group may have developed their NSP after having been classified one or two times as having inverse C7–T1 function. Naturally, NSP also occurs with the origin of pain from other levels as the upper and lower cervical syndromes (2). The incidence of inverse C7–T1 function was approximately 33% per year in this working environment. Thus, as time goes by, the risk of adding a new classification of inverse C7–T1 function to a previous one will increase and possibly also the risk for NSP might increase. If 33% per year is the incidence rate, a period of approximately seven years would be required to have had three classifications of inverse C7–T1 function in a population starting from none. However, we suggest that occasional periods of NSP may develop in a shorter time as a consequence of inverse C7–T1 function. Most probably the incidence rate is different in different environments and age groups.

The practical use of the inverse function as a diagnostic criterion has to be further evaluated. The inverse C7–T1 function, however, is regarded as a dysfunction that can give rise to "motion segment related pain" and was shown to be an important factor in the assessment of NSP. Further research introducing the CTR technique in clinical trials on patients with NSP is necessary in order to validate the clinical significance of invariable inverse C7–T1 function. Preliminary treatment trials performed by the authors including mobilization of hypomobile motion segments have shown that a lack of synchronous distribution of mobility can be re-established (15). However, re-established mobility can also revert back to the previous non-synchronous distribution (15). Further research is necessary.

CONCLUSION

Invariable C7–T1 mobility together with an inverse function was a risk factor related to the development of musculoskeletal NSP and was interpreted as a consequence of a non-synchronous distribution of mobility between the adjacent motion segments C7–T1 and T1–T2. Inverse C7–T1 function may become an objective diagnostic criterion of such musculoskeletal NSP with its origin in the cervico-thoracic articulations.

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