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WORK-RELATED CHRONIC NECK IMPAIRMENT

Neck Motion Analysis in Female Traverse Crane Operators

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ABSTRACT. Twenty-one female steel industry traverse crane operators with long-term sick-leave (3 (1–8) years) due to chronic neck disability underwent careful analysis of case history, physical status and electrogoniometric three-dimensional recordings of active neck motion. Results were compared with those from working female crane operators having identical work posture and tasks and, further, with a group of working female clerks. The sick-listed crane operators had previous frequent contacts with the primary health care because of complaints from the neck and back. In comparison with the reference groups, the sick-listed crane operators showed tenderness of the trapezius and levator scapulae muscles and a short neck stature in combination with impaired active neck motion range with reduced motion speed. The motion pattern was however unchanged. The findings are consistent with the clinical picture of chronic neck myalgia that persisted despite long-term absence from the previous exposure to high static work load upon the neck-shoulders.

Key words: industry, myofascial pain syndromes, neck, pattern of motion, range of motion.

Neck-shoulder diseases contribute to a high proportion of long-term sick-leaves in light manufacturing workshops, particularly in female labourers (6, 12). Exposure to high static loads upon the neck and shoulder-stabilizing muscles over long periods of time is a common factor besides chronic microtrauma and occupational incidents (7, 8). Epidemiological studies indicate a poor prognosis as to overall sick-leave (13), although physical findings are quite few. Tender, tense neck muscles with localized pain and fatigue are common complaints. Neck motion may be somewhat restricted although the physical status hardly correlates with current pain symptoms (11, 16). The neck motion pattern has been studied previously in healthy individuals (1, 2, 5, 10). So far, objective studies are few as regards the neck function in this category of patients (9).

Work-related neck impairment caused by chronic trapezius myalgia has recently been studied in female assembly workers (14, 15). Biopsy studies of the trapezius muscle indicated a discrete mitochondrial dysfunction of the Type 1 fibers ("ragged red" fibers) and examinations with laser-Doppler techniques gave evidence of a reduced local muscle blood flow correlating with the myalgia and previous static load. The abnormalities were present despite the fact that the patients had long-term sick-leave at the time of the examinations. This suggests a long-lasting impairment of the neck function that may be difficult to ascertain at clinical examination. There is obviously a need for more objective methods to improve the specificity of the physical examination of these disabilities.

In the present study, a 3-dimensional motion analysis of the neck was performed in female traverse crane operators who had long-term sick-leave due to work-related chronic neck pain that referred to monotonous work posture causing high static load to the neck-shoulder muscles. Reference groups of operators at work and female clerks at work were studied for comparison.

METHODS

Twenty-one female crane operators aged 46 (34–60) years had long-term work absence because of chronic disability of the neck-shoulders causing sick-leave for the last 3 (1–8) years. Seventeen had full-time and 4 half-time sick-leave. All had dominating neck pain/stiffness, 17 also reporting pain from the shoulders, upper extremities and lower back. They had been working full-time for the previous 14 (1–24) years in a sitting position (Fig. 1) with forward bending of the trunk and high degree of psychological concentration upon the work tasks which caused high static loads upon the neck and shoulder-stabilizing muscles. They were compared with a group of 22 female, non-absent crane operators aged 38 (21–62) years, doing similar work full-time (one half-time) since 12 (1–27) years. Their earlier work absence for complaints from the neck, shoulders or back totalled 2 (0–24) weeks.

The findings in the crane operators were also compared with

Fig. 1. The crane operators all had a forward tilted sitting position causing high static loads upon the neck and shoulder-stabilizing muscles.

those in a reference group of 21 female clerks aged 37 (20–60) years, 19 working full-time and 2 half-time since 16 (1–40) years. None had previous sick-leave from neck-, shoulder- or low back pain.

Using a self-administered questionnaire musculoskeletal complaints were carefully recorded, as well as symptoms of rheumatic, neurological or vascular nature, medication and leisure activities. The latter were scaled 1–4: 1 = no physical activity; 2 = unregular light physical acitivity such as walking, cycling or gardening; 3 = regular physical activity weekly such as jogging, swimming, gymnastics, heavy gardening; 4 = heavy physical training and/or competition athletics. A thorough physical examination was performed by a specialist in orthopaedic surgery (M. Å.) as regards the neck, shoulders, upper extremities and the spine. The posture was assessed in erect position, thoracic kyphosis and lumbar lordosis being measured with a Kyphometer (3). Lateral trunk bending was measured as the angle formed in the frontal plane between the upper thoracic spine and the horizontal line joining the iliac crests, the pelvis held strictly in horizontal position by the examiner. Trunk rotation was measured as the angle formed in the transverse plane between the line joining the humero-scapular joints and the line joining the iliac crests, the pelvis held strictly in the frontal plane by the examiner. In both cases a simple goniometer was used. Routine neurological examination was performed including nerve root compression test, percussion of the median and ulnar nerves at entrapment sites, assessments of gross motor power, tendon reflexes and light-touch sensibility C5-Th1. Clinical signs of cervical myelopathy were looked for.

Electrogoniometric 3-dimensional motion analysis of the neck was performed, as described previously (1). The total range of active motion in the three planes was recorded. The time required by the patient to complete the standardized examination of active neck motion was determined. Subjects

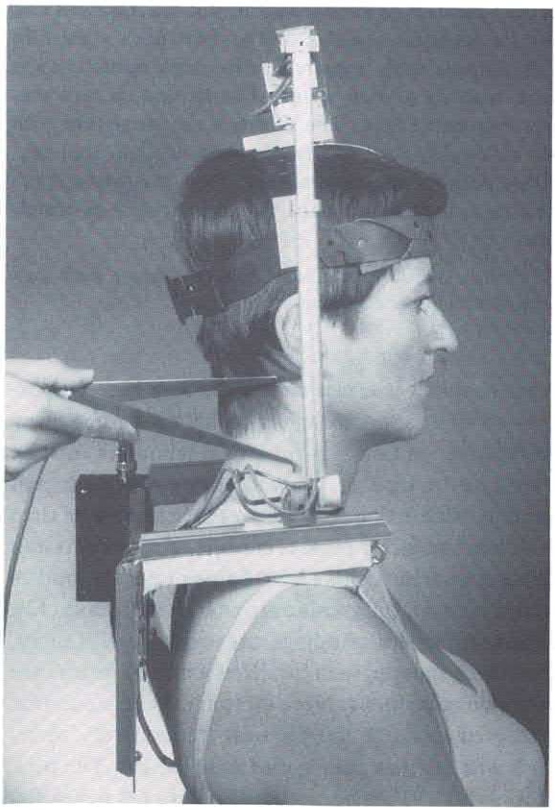

Fig. 2. The electrogoniometric equipment properly attached to the head and shoulders. Measurement of neck length (see text).

Table I. *Current muskuloskeletal complaints*

p-values show statistical analysis (Student's *t*-test) between groups

Item	Sick-listed crane operators $N=21$		Working crane operators $N=22$		Working clerks $N=21$
Neck pain/stiffness	21	$p<0.001$	9	NS	7
		$p<0.001$			
Shoulder pain	13	$p<0.05$	7	NS	3
		$p<0.001$			
Interscapular pain	13	$p<0.001$	3	NS	2
		$p<0.001$			
Low back pain	13	$p<0.001$	3	NS	1
		$p<0.001$			
Upper arm pain	6	NS	3	NS	2
Elbow pain	6	$p<0.05$	1	NS	1
		$p<0.05$			
Forearm pain	5	NS	3	NS	0
		$p<0.05$			
Wrist/hand pain	12	$p<0.05$	5	$p<0.05$	0
		$p<0.001$			
White fingers when cold	3	NS	4	NS	1
Any tingling sensations	16	$p<0.01$	8	$p<0.001$	1
		$p<0.001$			
Pelvis/hip pain	8	NS	3	NS	1
		$p<0.01$			
Femur/knee pain	4	NS	2	NS	0
		$p<0.05$			
Foreleg pain	2	NS	0	NS	0
Ankle/foot pain	3	NS	1	NS	0

were investigated in a relaxed sitting position and were requested to move the head in the following sequence: flexion, rotation right–left in the flexed position, extension, rotation right–left in the extended position, rotation right–left in neutral head position and lateral bending right–left. As exact movements as possible were requested with no excessive strain or discomfort. The distance from the tip of the mastoid process to the centre of the flexion-extension goniometer was recorded with the individual sitting relaxed with the equipment firmly attached to the head as well as to the shoulders (Fig. 2). This gave a relative measure of neck length. Neck width at the base was measured with callipers.

For statistical evaluation two-tailed Student's *t*-test and Fisher's exact test were performed. A probability level of 5% was considered significant.

RESULTS

Case history

Apart from pain/stiffness of the neck the sick-listed crane operators frequently complained of shoulder pain, interscapular pain and low back pain. In addition, they frequently experienced tingling sensations from the body. Complaints from the elbows, wrists and hands were recorded at high frequency (Table I). The sick-listed crane operators frequently reported symptoms like "weak back, lumbago, sciatica and joint pain" of more diffuse character (Table II). They seemed to have undergone surgical treatment more frequently. They often used pharmaceutics and complained of depression, sleeplessness and tiredness. Working operators and clerks had but few complaints, generally. They might therefore represent a normal population (Tables I and II).

Physical examination

As regards body constitution, sick-listed crane operators seemed to have short neck stature, even in consideration of relatively short body length. Measured lumbar lordosis was less in the two groups of operators than in the clerks (Table III). Sick-listed operators seemed to have impaired trunk bending laterally and arm elevation bilaterally (Table IV). They experienced evident local tenderness at palpation of the

Table II. *Various illnesses and complaints and leisure activities (scaled 1–4, numbers refer to the means)*
p-values show statistical analysis (Student's *t*-test) between groups

Item	Sick-listed crane operators $N=21$		Working crane operators $N=22$		Working clerks $N=21$
Asthma, allergic diathesis	5	NS	3	NS	5
Diabetes mellitus	0	NS	1	NS	2
Frequent rhinitis	1	NS	2	NS	1
Gastro-intestinal diseases	6	NS	1	NS	2
Proteinuri, nephrolithiasis	0	NS	0	NS	0
Struma, pathologic metabolism	0	NS	1	NS	0
Hearing loss	1	NS	2	NS	1
Sight loss	5	NS	2	NS	5
"Weak back", lumbago	14	$p<0.01$	6	NS	3
sciatica, joint pain		$p<0.001$			
Other major illness	1	NS	1	NS	0
Major trauma	0	NS	0	NS	0
Previous surgery	9	$p<0.05$	3	NS	4
Intake of pharmaceutics	12	$p<0.05$	6	NS	5
		$p<0.05$			
Often anxious or worried	1	NS	2	NS	3
Often depressed	8	$p<0.01$	1	NS	1
		$p<0.01$			
Often restless	3	NS	4	NS	2
Often irritated or impatient	6	NS	3	NS	2
Often headache	10	NS	6	NS	4
Sleeping problems	11	$p<0.05$	4	NS	3
		$p<0.01$			
Often unconcentrated	2	NS	0	NS	0
Often tired	9	NS	5	NS	3
		$p<0.05$			
Smoked cigarettes daily	6 ± 7	NS	10 ± 9	$p<0.01$	2 ± 6
Leisure activities	2	NS	2	NS	2

upper portion of the trapezius muscles at high frequency, as well as the levator scapulae muscles and the rotator cuffs of the shoulders, in particular on the right side (approximately one third of the cases) (Table V).

Neurological examination was normal in all individuals.

Motion analysis of the neck

The sick-listed crane operators showed in comparison to both reference groups impaired range of active motion in all three planes with significantly ($p<0.001$) reduced flexion/extension as well as rotation examined in neutral, flexed and extended head position (Table VI). Lateral flexion was also significantly reduced ($p<0.01$). The working crane operators did not differ from the clerks other than by a reduced mean degree of extension during rotation in extended head position. The pattern of active motion did not show any differences between the groups, i.e. differences in motion range were equally distributed in the three planes. There were no differences as to the ratio between rotation and lateral flexion during active head rotation and lateral bending. Sick-listed operators needed increased time to complete the standardized sequence of active movements in the motion analysis ($p<0.001$ when compared with the clerks and $p<0.05$ when compared with the working crane operators). No differences were found whatsoever between working crane operators and clerks.

DISCUSSION

Minor neck complaints are common in the female population. These were reported in a third of working crane operators and working clerks. The sick-listed

Table III. *Body constitution and posture in the erect position*

Means ± one standard deviation. *p*-values show statistical analysis (Student's *t*-test) between groups

Item	Sick-listed crane operators $N=21$		Working crane operators $N=22$		Working clerks $N=21$
Body length (cm)	163±8	NS	165±7	NS	165±5
		$p<0.05$			
Body weight (kg)	67±13	NS	66±13	NS	61±9
Neck "length" (cm)	6.6±1.1	$p<0.05$	7.6±1.3	NS	7.3±1.1
Neck width (cm)	9.8±0.8	NS	10±0.9	NS	9.9±0.6
Thoracic kyphosis (degrees)	40±6	NS	39±6	NS	40±7
Lumbar lordosis (degrees)	31±6	NS	30±6	$p<0.01$	35±6
		$p<0.05$			
Niveau-difference of scapulae in erect position (cm)	0.5±0.8	NS	0.3±0.8	NS	0.2±0.6
Niveau-difference of iliac crests in erect position (cm)	0.3±0.5	NS	0.2±0.4	NS	0.2±0.5

crane operators had neck–shoulder disability that persisted despite work absence for the last 3 (1–8) years. This finding is similar to that reported previously in studies of female assembly workers (14, 15).

As regards the previous sick history, sick-listed operators had during the years maintained frequent contacts with the primary health care for complaints like "weak back", lumbago, sciatica and joint pain of diffuse character. Notably, they also seemed to have undergone surgical treatment for various ailments more frequently. In addition, half of them complained of depression, sleeplessness and tiredness. These ailments caused frequent sick-leave although no specific morbidity was encountered.

At our clinical examination, chronic neck myalgia was found to be the predominant disorder in almost all of the sick-listed crane operators. As regards physical findings, their somewhat short neck stature could well be due to constantly elevated shoulders second-

Table IV. *Results of physical examination*

Active motion range of the trunk and shoulders. Means ± one standard deviation. *p*-values show statistical analysis (Student's *t*-test) between groups

Item	Sick-listed crane operators $N=21$		Working crane operators $N=22$		Working clerks $N=21$
Lateral trunk bending degrees	46±11	$p<0.01$	56±13	NS	56±10
		$p<0.01$			
Trunk rotation (degrees)	47±15	NS	53±16	NS	53±11
Arm elevation right (degrees)	165±32	$p<0.05$	180±0	NS	180±0
		$p<0.05$			
Arm elevation left (degrees)	167±27	$p<0.05$	180±0	NS	180±0
		$p<0.05$			
External upper arm rotation right (degrees)	67±8	NS	69±5	NS	69±7
External upper arm rotation left (degrees)	67±8	NS	69±5	NS	67±8

Table V. *Tenderness at palpation*

p-values show statistical analysis (Student's *t*-test) between groups

Item	Sick-listed crane operators $N=21$		Working crane operators $N=22$		Working clerks $N=21$
Right/left sterno-cleidomastoideus	0	NS	0	NS	1
Right trapezius	16	$p<0.01$	7	NS	4
		$p<0.001$			
Left trapezius	11	NS	8	NS	5
Right levator scapulae	9	NS	4	NS	1
		$p<0.01$			
Left trapezius	11	NS	8	NS	5
Left levator scapulae	8	NS	3	NS	2
		$p<0.05$			
Right rotator cuff	6	$p<0.01$	0	NS	0
		$p<0.01$			
Left rotator cuff	4	NS	0	NS	1
		$p<0.05$			

ary to the increased muscular tenseness and noted tenderness of particularly the right trapezius and levator scapulae muscles. Their complaints of low back pain with a noted slightly reduced lumbar lordosis might be related to previous work posture with constant sitting and monotonous handling of manoeuvre tools under constant high psychological concentration. This could also have caused chronic irritation of the rotator cuff of the shoulders that together with the chronic neck myalgia seemed to explain the noted slight reduction of active arm elevation.

The symmetrical impairment of active motion range of the head and neck and decreased speed of active motion are consistent with the clinical picture

Table VI. *Electrogoniometric analysis of the neck motion*

Active motion range in the three planes (degrees) with rotation recorded in neutral, flexed and hyperextended head position, and time required to complete the motion analysis (seconds). *p*-values show statistical analysis (Student's *t*-test) between groups. Means ±1 SD

Item	Sick-listed crane operators $N=21$		Working crane operators $N=22$		Working clerks $N=21$
Flexion/extension	100±19	$p<0.001$	122±12	NS	127±16
		$p<0.001$			
Rotation	124±23	$p<0.001$	148±12	NS	155±14
Neutral pos.		$p<0.001$			
	88±17	$p<0.001$	106±10	NS	100±11
Flexed pos.		$p<0.05$			
	84±21	$p<0.001$	106±19	NS	98±19
Extended pos.		$p<0.05$			
Lateral flexion	64±16	$p<0.01$	77±12	NS	79±15
		$p<0.01$			
Time	40.0±8.4	$p<0.05$	34.8±6.0	NS	31.9±4.4
		$p<0.001$			

of chronic neck myalgia in the sick-listed crane operators. The present findings can hardly be explained only by the age difference between the sick-listed (mean 46 years) and working (mean 38 years) crane operators. In this age interval Ferlic (4) could not demonstrate any significant decrease of head and neck mobility in the "normal" cervical spine in 199 tested subjects. Thus, the limitation of active neck motion was certainly due to the noted tenderness of the neck muscles, i.e. the trapezius and levator scapulae muscles.

The fact that this abnormality could be demonstrated in sick-listed crane operators with long-term absence from work is in agreement with previous findings in female assembly workers with chronic, work-related trapezius myalgia (14, 15). They showed local pain and reduced blood flow despite their long-term absence from the static load at work (15). This suggests a more or less persisting disturbance of mechanisms regulating the local muscle blood flow.

Summarizing, we found muscular tenderness in combination with a short neck stature and decreased mobility of the head and neck in the sick-listed crane operators. Neck motion pattern was not altered. This kind of neck impairment and disability should be prevented. Once developed, physical therapy seems to have limited effect in restoring the neck function and full working capacity. Preventive physical training is recommended besides possible ergonomic measures.

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REFERENCES

1. Ålund, M. & Larsson, S.-E.: Three-dimensional analysis of neck motion. A clinical method. SPINE *15*: 87–91, 1990.
2. Brown, R., Burstein, A., Nash, C. & Schock, C.: Spinal analysis using a three-dimensional radiographic technique. J Biomechanics *9*: 355–365, 1976.
3. Debrunner, H. U.: Das Kyphometer. Z Orthop *110*: 389–392, 1972.
4. Ferlic, D.: The range of motion of the "normal" cervical spine. Bull Johns Hopk Hosp *110*: 59–65, 1962.
5. Fielding, J. W.: Cineroentgenography of the normal cervical spine. J Bone Joint Surg Am *39*: 1280–1288, 1957.
6. Hult, L.: The Munkfors Investigation. A study of the frequency and causes of the stiff neck-brachialgia and lumbago-sciatica syndromes, as well as observations on certain signs and symptoms from the dorsal spine and the joints of the extremities in industrial and forest workers. Acta Orthop Scand, Suppl 16: 1–31, 1954.
7. Hult, L.: Cervical, dorsal and lumbar spinal syndromes. Acta Orthop Scand, Suppl 17: 1–35, 1954.
8. Jeffreys, E.: Disorders of the Cervical Spine, pp. 90–105. Butterworths, London, 1980.
9. Johnston, W., Vorro, J. & Hubbard, R.: Clinical/biomechanic correlates for cervical function. Part I. A kinematic study. Journal of AOA *85*: 429–437, 1985.
10. Jones, M.: Cineradiographic studies of the normal cervical spine. Calif Med *93*: 293–296, 1960.
11. Jordan, A., Mehlsen, J. & Lund, T.: Deficiency of neck muscles in cervicobrachial syndrome. IX Scandinavian Congress of Clinical Physiology, Lund, Sweden (Congress abstract), 1991.
12. Kvarnström, S.: Occurrence of musculoskeletal disorders in a manufacturing industry with special attention to occupational shoulder disorders. Scand J Rehab Med, Suppl 8: 1–114, 1983.
13. Kvarnström, S.: Arbetsrelaterade problem i halsrygg och skuldra utgör ett växande problem i företagshälsovården. Läkartidningen *82*: 1590–1592, 1985.
14. Larsson, S.-E., Bengtsson, A., Bodegård, L., Henriksson, K. G. & Larsson, J.: Muscle changes in work-related chronic myalgia. Acta Orthop Scand *59*: 552–556, 1988.
15. Larsson, S.-E., Bodegård, L., Henriksson, K. G. & Öberg, P. Å.: Chronic trapezius myalgia. Morphology and blood flow studied in 17 patients. Acta Orthop Scand *61*: 394–398, 1990.
16. Schoening, H. A. & Hannan, V.: Factors related to cervical spine mobility. Part 1. Arch Phys med *45*: 602–609, 1964.

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