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MECHANICAL PERFORMANCE, LEVEL OF CONTINUOUS CONTRACTION AND MUSCLE PAIN SYMPTOMS IN HOME CARE PERSONNEL

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ABSTRACT. The interrelationships between reported complaints, clinical status, mechanical performance and EMG pattern of the shoulder flexors and the knee extensors, respectively, during maximum dynamic contractions were investigated. A group of 97 randomly selected women employed in the home care service participated. Those who reported complaints had more clincal findings, such as reduced mobility, tender points and muscle tightness, than non-complainers. The level of muscle activity during the passive part of the contraction cycle was significantly higher in the shoulder flexors than in the knee extensors. Subjects without reported complaints who had been employed for more than ten years had a significantly lower activity level in the shoulder muscles than subjects without complaints who had been employed for a shorter time. We suggest that a high muscle tension level between contractions might precede muscle pain. A cluster analysis including sociodemographic, clinical and physiological variables revealed different subgroups, which points to the need to investigate the work situation in a multivariate way.

Key words: biomechanics, dynamic, EMG, human, muscle tension, musculoskeletal complaints, physiotherapy, home care service.

The Swedish home care service has been expanding during the past few years, owing to reorganisation of the care for the elderly. An increasing problem at present is frequent sick leave in the personnel group due to musculoskeletal complaints and high incidence of reported occupational injuries/diseases in the musculoskeletal system.

One proposed explanation for work-related muscular pain, which often affects the shoulder muscles, is the conflicting demands between the motor control of postural activity needed for rhythmic movements and that needed for skilled manipulations (6). A model proposed by Johansson & Sojka emphasizes the role of the gamma motoneuron system in perpetuating and spreading muscle tension (17). Isokinetic muscle testing is a method frequently used for measuring dynamic strength and endurance. Our group has used repeated isokinetic contractions, to investigate muscle tension during maximum repetitive shoulder flexions (7, 8, 10). In these studies both in clinically healthy subjects and in patients with myalgia, differences in the ability to relax between repetitive maximum shoulder flexions have been found (9). Thus far our interpretation of these findings is that a decreased ability to relax will give a more or less continuous load particularly on the low threshold fibres (type-1). In line with this interpretation of a possible risk of overuse of the low threshold fibres several studies have shown pathological findings located to the type-1 muscle fibres in work-related myalgia (13, 22). Recently, Larsson et al. (23) reported a reduction in local blood flow for patients with chronic work-related trapezius myalgia and this in turn was correlated with mitochondrial changes in the type-1 fibres.

Questionnaires have been developed and used to identify occupational risk groups and risk factors for complaints in the musculoskeletal system (20). However, these kinds of effect variables (i.e. prevalence of complaints in the musculoskeletal system for a defined time period) have only been partially validated versus clinical status (18). The very existence of some of the complaints, sometimes labelled as "repetition strain injury" (RSI), and whether or not they are really work-related has been questioned (4). The degree to which reported work-related complaints from the musculoskeletal system correspond to clinical findings and reduced muscle function is poorly known.

Aim of the study

The aim of the study was to investigate whether reported symptoms and clinical findings were related to mechanical and electromyographic findings. It was also of interest to test the hypothesis that the muscle activity of the knee extensors between active contractions (measured as signal amplitude ratio) was lower than that of the shoulder flexors, owing to simpler biomechanical demands for the muscles acting over the knee joint than for those acting over the gleno-humeral joint.

SUBJECTS

A total of 160 employees in the central home care service district of Umeå, Sweden, were randomly selected and asked to participate in a program which included both a number of pre- and aftertests and a one year training program. Of the 160 selected, 54 subjects rejected participation and 9 subjects were rejected after a medical check-up (see below) because of physical unfitness such as hypertonia, gonarthrosis and/or working conditions differing from the whole group. Thus, the group consisted of 97 women working at least 50% part-time or more either in the open home care services or at a service house. Working time per week was 32 ± 5 hours (range: 20–37.5). The women had worked for 86 ± 83 months (range: 3–360 months). The mean age was 40 ± 13 years (range: 19–65 years) and mean weight 66 ± 11 kg.

METHODS

All subjects went through the procedures in the same order; first a routine medical check-up and then filling in a questionnaire, before being examined by a physiotherapist (PT). The strength and endurance of the shoulder flexors and the knee extensors were then tested using an isokinetic dynamometer.

The routine medical check-up consisted of anamnesis for heart-lung disease, allergy, and disease of the musculoskeletal system, and a physical examination of general condition, heart, lungs, blood pressure, spine and extremity joints, and locomotion.

The questionnaire consisted partly of questions about localisation, intensity and duration of complaints in the musculoskeletal system, some questions being taken from the Questionnaire of the Nordic Council of Ministers (20), and partly of questions concerning physical and social working conditions. Most of these results will be presented elsewhere. In this study the 7 day prevalence of complaints from 9 different anatomical regions is reported.

The physiotherapy check-up was performed in the same manner by the same physiotherapist (J. Elert) both before and after training. The subjects were instructed not to tell the examiner of their reports on the questionnaire, but to indicate when certain tests produced pain. In order to make a record of the examination a check-list was constructed. The purpose of the check-list was to serve as a convenient way of recording the observations performed in an ordinary clinical investigation. When possible, commonly used and/or tested scales were applied without any special equipment. The check-list included coordination disturbances, deviation in posture, range of motion, muscle tightness, provocation tests and tender points. The scale had a grading from 0 to 2 corresponding roughly to the clinical "normal" (0), "slight" (1) and "great" (2) reduction or deviation with a manual containing definitions of each grade. For deviation in posture a dichotomized score was used. Back muscles were palpated and tender points were considered to be present when the patients reported pain or displayed pain reactions (for example, trying to avoid the pressure). Interspinal ligaments were palpated ("the Key test"; (15)) and the spinal segments in the thoracal and lumbar regions were loaded using "the Springing tests" (21). The investigation was not primarily intended to recognize patients with primary fibromyalgia, but to quantify different findings from the musculoskeletal system. Immediately after the physiotherapy examination (while the subject dressed) the examiner made a preliminary physiotherapy diagnosis of the symptoms as would have been done if the subject had been consulting the physiotherapist for treatment. No definite critera could be predefined in order to fit all the different symptoms occurring into diagnostic categories. Commonly accepted criteria were used and will be presented in the results.

The strength and endurance tests were performed using an isokinetic dynamometer (Cybex II). The subjects were seated with 90° hip flexion and 90° knee flexion in a specially constructed chair which enabled adequate and comfortable fixture (10, 11).

First, the subjects performed 100 maximum repeated shoulder flexions at the angular velocity of 1.05 rad s^{-1} (60° s^{-1}). The range of motion investigated was from 30° of flexion to 90°. The axis of the dynamometer was approximately aligned to the flexion-extension axis of the gleno-humeral joint. EMG signals were recorded from the descendent part of the trapezius, the anterior part of the deltoid, the infraspinatus and the biceps brachii muscles on the dominant side (11).

Secondly, after ten minutes rest, the subjects performed 100 maximum repeated knee extensions at 1.57 rad s^{-1} (90° s^{-1}). The range of motion investigated was from 90° of knee flexion to 0°. The flexion-extension axis of the knee joint was aligned as closely as possible with the axis of the dynamometer. EMG signals from the vastus lateralis, the rectus femoris and the vastus medialis of the quadriceps muscle on the dominant side were obtained throughout the experiment (8). Prior to each endurance test each subject was taught the contraction performance. Thus, the subjects were instructed at low submaximal levels to perform an active contraction (shoulder flexion respectively knee extension) (= active phase) followed by a total relaxation (i.e. a passive shoulder extension and a passive knee flexion, respectively) and follow the lever arm passively (using the gravitational torque) down to the beginning of the investigated active range of motion (= passive phase). The subject was instructed to perform a new active contraction immediately (without any pause) when this position was achieved. In this manner the contraction frequency was standardized and the active contraction times were approximately the same (1 s) both in the shoulder flexions and the knee extensions.

The EMG signals were registered using surface electrodes (centre to centre distance: 20 mm). The signals from the dynamometer and the EMG signals were recorded on a tape recorder for analysis using a specially designed computer program (11). This program determined mean power frequency (MPF) and root mean square (RMS) of each EMG signal in real time as well as peak torque (Nm) and work (J) for each contraction. The level of activity between the maximum contractions was calculated as a ratio (in per cent) between the mean signal amplitude of the EMG signal during

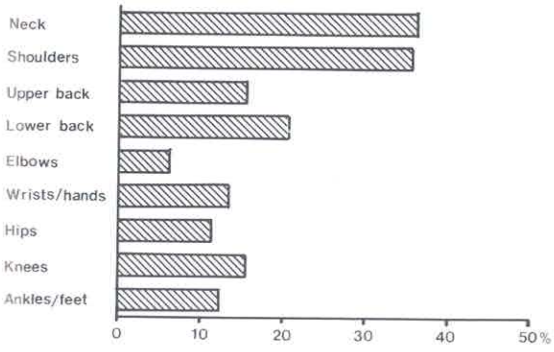

Fig. 1. Seven day prevalence of complaints from different anatomical regions in percentage of the total number of subjects ($n=97$).

the passive phase and the active phase of each contraction cycle for each muscle; the signal amplitude ratio (SAR).

Statistics

All statistics were performed with the statistical package NCSS version 5.01. The results will be presented as mean values ± one standard deviation. Student's *t*-test was used for determining differences between means and the chi-square test was used for determining differences in proportion. When creating indices for the physiotherapy status each area of the status was factor analysed separately. Eigenvalues ≥ 1.00 were considered as significant and the most important variable, that is with the highest load on the significant rotated factors, was included in the indices, all being given the same weight. For instance, if cervical lordosis and lumbar lordosis turned up in the same factor, only the item with the highest load was retained. Thereby the number of items could be reduced. A cluster analysis was made for classifying the materials into subsets containing subjects with similar characteristics. The cluster analysis in the NCSS is based on the K-means algorithm, in which the objective is to divide N observations with P dimensions (variables) into K clusters so that the within-cluster sum of squares is minimized (14). Variables were included by rational reasoning, with the objective of including important background variables and variables representing different aspects of clinical and physiological findings. Linear Discriminant Analysis was used to investigate whether the clusters were significantly different and which of the variables separated the clusters.

RESULTS

Questionnaire

A total of 36% of the subjects reported complaints in the neck and 35% in the shoulders, during the past seven days and 22% reported complaints from the lumbar region (Fig. 1). Less than 20% reported complaints from each of the other regions. Thirty-seven per cent of the subjects did not report any complaints at all during the past seven days and 52% were without complaints from the neck or shoulders.

Examination

The physiotherapist's functional diagnosis. Ten persons were judged to have the diagnosis "localised trapezius myalgia" in the light of the pain provoked by palpation and stretching of the muscle. Pain from muscles in more than one anatomical site was found in twelve cases. Twelve subjects were diagnosed as having diffuse neck pain (pain not provoked by palpation or stretching of muscles). Symptoms of thoracic outlet syndrome (TOS), defined as reported radiculating pain or numbness provoked by a hands-up test within three minutes, were found in twelve cases. Four persons were not able to perform a hands-up test for more than 1 minute. Two persons displayed positive radiculating symptoms from a compression test in the neck.

Tendinitis was considered present when two out of three of the following tests caused pain: palpation of tendon insertion, static contraction of the muscle and stretching of the muscle. Thus, five persons had supraspinatus tendinitis and one infraspinatus tendinitis. Three had epicondylitis. Only eight persons had symptoms that were interpreted as lumbalgia, while eleven had trochanteritis defined as pain in the trochanter region and pain when the gluteal muscles were stretched or contracted. One person was found to have pain in the wrist and five persons in the knee.

Findings from the physiotherapy check-list. Indices were constructed for the various aspects investigated in the check-list, in which the items found most important from a factor analysis were included. Thus, six different indices were created: neck mobility, shoulder mobility, lumbar mobility, posture, tendinitis, and muscle tightness (Table I). The number of locations from which a subject reported pain in the spine when the physiotherapist performed the Springing and the Key tests, was summated as well as the number of palpated tender points in muscles (the palpation index), thus forming two additional indices (Table I).

The physiotherapy diagnosis diffuse neck pain was found significantly more frequently in the group reporting complaints from at least one anatomical region during the past 7 days (the complaint group). The complaint group had significantly more findings on all the status indices, except for the lumbar mobility index, than those reporting no complaints (Table II). The subjects reporting complaints in the neck and

Table I. *Indices created by items on the check-list (possible max is the total sum of the scores possible to obtain on the index)*

Posture
Reduced lumbar lordosis
Increased cervical lordosis
Elevated shoulders
Slight scoliosis
(Possible max = 4)

Lumbar mobility
Right flexion; reduced
Left flexion; reduced
Right rotation; pain
Left rotation; pain
Hypermobility
(Possible max = 9)

Neck mobility
Right flexion; reduced
Left flexion; reduced
Neck extension; reduced
Hypermobility
(Possible max = 7)

Tendinitis
Infraspinatus left
Supraspinatus right
Lateral epicondilitis right
Piriformis tendinitis left
(Possible max = 12)

Shoulder mobility
Right flexion; pain
Left flexion; pain
Right abduction; pain
Right inward rotation; pain
Right outward rotation; pain
(Possible max = 10)

Muscle tightness
Right trapezius; pain
Left trapezius; pain
Left levator scapulae; pain
Right trapezius; tight
Right hamstrings; pain
Right hamstrings; tight
Left hamstring; pain
Left hamstring; tight
(Possible max = 16)

Springing and Key tests
(Possible max = unknown)

Palpation
(Possible max = unknown)

Table II. *Frequency of physiotherapy diagnosis (absolute frequency) and number of physiotherapy findings (according to indices) found in the group with reported complaints from at least one body region compared with the group with no complaints*

PT diagnosis	0 complaints (n=36)		1–9 complaints (n=61)
Trapezius myalgia	1		9
Piriformis tendinitis	2		9
Lumbar pain	3		5
Diffuse neck pain	1	*	11
Supraspinatus tendinitis	1		4
Total	8	***	38
Index scores			
Posture	0.95	*	1.39
Lumbar mobility	0.94		1.11
Neck mobility	0.77	*	1.25
Tendinitis	0.44	***	1.22
Shoulder mobility	0.18	**	0.77
Muscle tightness	1.38	*	2.23
Springing and Key tests	0.55	**	2.03
Palpation	1.75	**	3.27

* Denotes significant differences.

shoulder had significantly higher scores on the indices of neck mobility, tendinitis, shoulder mobility, Springing and Key tets and palpation than those not reporting complaints (Table III).

Mechanical performance and MPF

Owing to problems with data recordings on the tape recorder three persons had to be excluded from the comparative data of the shoulder flexion test. A pattern with decreases in mechanical performance during the initial 50 contractions, the fatigue phase, down to stable levels, the endurance level, was found (Table IV). There were also significant decreases in mean power frequency parallel to the mechanical performance. Six persons did not manage to perform 100 shoulder flexions. These differed from the rest by having higher mechanical performance and higher mean power frequency, especially in the trapezius muscle (significant) at the initial contraction (85±8 Hz versus 75±11 Hz).

A pattern similar to that of the shoulder flexors with an initial fatigue phase and a stable endurance level was found for the knee extensors (Table IV). Only one person did not manage to perform 100 maximum knee extensions.

There was a significant positive correlation between peak torque initially in the shoulder flexors and the knee extensors (r=0.27), but this was not found for the mechanical variable work.

The signal amplitude ratio (SAR)

The signal amplitude ratio showed rather prominent interindividual differences for the four different muscles (Table V). For the subsample without reported symptoms in the neck and shoulder regions the SAR of the four muscles of the shoulder flexors correlated significantly at the initial contraction. In a similar way, the three muscles of the lower limb showed significant correlations. Moreover no significant correlations existed between total SAR and weight and height, respectively, for the shoulder flexors and the knee extensors. There was a decrease in signal ampli-

Table III. *Comparison between reported complaints in the neck-shoulder and back regions and PT findings*

	Neck-Shoulder complaints			Back complaints		
PT findings (Index scores)	0 compl.		1–2 compl.	0 compl.		1 compl.
Posture	1.12		1.37	1.14		1.55
Lumbar mobility	1.03		1.06	0.92		1.55
Neck mobility	0.71	***	1.47	1.10		0.97
Tendinitis	0.51	***	1.40	0.77	**	1.55
Shoulder mobility	0.20	**	0.93	0.53		0.61
Muscle tightness	1.60		2.32	1.76		2.52
Springing and Key tests	0.96	*	2.06	1.16		2.70
Palpation	1.94	**	3.56	2.29	**	4.30

* Denotes significant differences.

tude ratio throughout the test. A total ratio (the average of the four shoulder muscles) was calculated and decreased from 19% at the initial contraction down to 14% at the endurance level. The persons who were not able to perform 100 contractions had a higher signal amplitude ratio (mean: 22%) at the initial contraction.

In the knee flexors the total signal amplitude ratio of the knee extensors (an average of the three knee extensor muscles) was initially 11%, dropping to 9% at the endurance level. A significant higher total SAR was found in the shoulder muscles than in the knee extensors. The total ratio of the shoulder flexors at the endurance level correlated significantly and positively with the total ratio of the knee extensors ($r=0.28$).

SAR, mechanical performance and MPF

The subjects were sorted into two groups according to whether their amplitude ratio at the endurance level was higher or lower than 15% in the shoulder flexors. The group below this SAR contained 57 subjects while the group with a higher ratio consisted of 31 subjects. The group with a high SAR had a significantly lower absolute work plateau (25±5 J versus 31±6 J) and relative work levels (55±16% versus 72±52%). The initial MPF in trapezius was significantly higher for the group with a low SAR (78±11 Hz versus 71±11 Hz, respectively). The initial peak torque of the knee extensor correlated positively and significantly with the total SAR of the knee extensors.

Table IV. *Mechanical performance (±1 SD) at the initial contraction and at the endurance level*

	Shoulder flexion	Knee extension
Peak torque initial (Nm)	65±15	108±20
Peak torque at endurance level (Nm)	40±7	71±15
Relative peak torque level (%)	63±13	66±13
Initial work (J)	48±15	123±31
Work at endurance level (J)	29±7	83±20
Relative work level (%)	67±44	69±13

SAR, reported complaints and PT findings

There was no significant difference in SAR in the upper extremity for those reporting complaints in the

Table V. *Signal amplitude ratios (±1 SD) at the initial contraction (denoted init) and at the endurance level (denoted end)*

	Mean (%)	Range (%)
Trapezius SAR, init	20±12	0–65
Deltoid SAR, init	21±11	3–76
Trapezius SAR, end	14±9	0–36
Deltoid SAR, end	14±10	2–56
Total shoulder SAR, init	19±9	3–54
Total shoulder SAR, end	14±8	3–44
Vastus lateralis SAR, init	10±12	0–86
Rectus femoris SAR, init	11±15	0–92
Vastus medialis SAR, init	12±10	0–63
Vastus lateralis SAR, end	8±6	0–27
Rectus femoris SAR, end	7±6	0–25
Vastus medialis SAR, end	10±8	0–44
Total knee extensor SAR, init	11±10	0–59
Total knee extensor SAR, end	9±5	2–24

Table VI. *The five groups (A–E) formed in the cluster analysis*

Variables in bold type were used and those denoted* were significant in the discriminant analysis. Variables in italics were not included in the cluster analysis. Mean value or frequency in per cent for each group is presented

	Groups				
	A $n=17$	B $n=22$	C $n=12$	D $n=17$	E $n=17$
Without complaints in neck or shoulders (%)	65	23	67	71	42
Complaints in the neck (%)	35	63	25	17	41
Complaints in the shoulder (%)	11	55	33	24	47
Complaints in the lumbar region (%)	0	50	0	17	23
Employment time* (months)	177	73	115	42	55
Working hours (hours)	33	30	33.5	33.5	31.5
Married* (%)	65	77	58	59	82
No. of children at home	0.40	0.61	0.58	0.65	1.17
Age* (years)	50	40	47	30	39
Neck mobility	0.94	1.61	1.16	0.5	1.03
Muscle tightness*	1.029	3.86	2.7	0.7	0.82
Palpation*	0.47	5.68	1.0	2.4	1.17
Shoulder work, initially (J)	43	50	46	47	51
Shoulder work at endurance level* (J)	32	28	25	25	32
Shoulder peak torque, initially (Nm)	57	64	60	65	72
Shoulder peak torque at endurance level (Nm)	41	40	35	40	43
Arm total signal amplitude ratio at endurance level* (%)	9.7	12.4	27	15.2	10.6
Trapezius SAR, endurance level (%)	10	12.7	22.7	15.2	10.3
Deltoid SAR, endurance level (%)	7.8	12.4	27	17.5	10.1
Leg peak torque, intitially* (Nm)	94	112	89	118	121
Leg peak torque, endurance level (Nm)	62	69	66	78	81
Leg work initially (J)	107	128	98	138	133
Lateralis SAR (%)	6.2	6.4	14.0	7.0	9.6
Rectus SAR (%)	6.3	7.4	9.8	6.0	8.9
Trapezius myalgia (%)	0	33	0	0	12
Trapezius MPF initially* (Hz)	80	75.8	63	84	65

neck and shoulder regions and those without complaints. However, nine out of the ten persons classified by the PT as having trapezius myalgia had a signal amplitude ratio above 12%, which was a significantly different distribution when compared with those without this diagnosis. There was a tendency, though not significant, for those who had symptoms to have a higher initial mechanical performance (peak torque and work).

In the subsample with employment for more than 10 years a tendency (non-significant) toward a lower signal amplitude ratio was seen when compared with those employment for a shorter time. When the persons with symptoms in the shoulder were excluded from the comparison a significantly lower SAR was found in the group that had worked more than 10 years in the home care service than in the group employed for a shorter time (10±4% and 15±9%, respectively). Also, a negative (significant) partial correlation ($r=0.29$) between the total ratio and employment time existed for the subjects without complaints from neck and shoulders, when the influence of the age of the subject was taken into consideration.

Cluster analysis and discriminant analysis

A cluster analysis was made for the purpose of subdividing the 97 subjects into groups. Eleven variables representing important sociodemographic variables and different aspects of clinical and physiological findings were chosen with the assistance of a variable selection procedure identifying the variables adding most to the explained variance: age, marital status, employment time, complaint from the neck and/or shoulder region, palpation, muscle tightness, initial peak torque, trapezius MPF initially, total SAR of the shoulder flexors at the endurance level, SAR of vastus lateralis at the endurance level and work of the shoulder flexors at the endurance level.

Five clusters were formed (Table VI):

- Group A (17 persons) with a low frequency of complaints, a long employment time, high age and low signal amplitude ratio of the arm and leg. This group also had low scores on the PT check-up.
- Group B (22 persons) in which the number of complaints and symptoms of the PT test was high. These had a higher signal amplitude ratio than Group A in the shoulder and a lower employment time and age. In this group 7 subjects classified as having myalgia were found as well as many other physiotherapy diagnoses.
- Group C (12 persons) with a very high signal amplitude ratio and an intermediate percentage of reported symptoms and a high degree of muscle tightness.
- Group D (17 subjects) with a high signal amplitude ratio and a low symptom report were young, mean age 29 years, and had a low employment time.
- Group E (17 subjects) with a rather high number of reported symptoms, while the physiotherapist found only a few symptoms and the signal amplitude ratio was low, were of middle age and had 1.3 children on average. Two subjects with trapezius myalgia belonged to this group.

In the next step a discriminant analysis was performed and this showed 9 significant variables adding to the explained variance (Table VI); palpation (F-value = 26), the total SAR of the shoulders (F-value = 17.8), trapezius MPF initially (F-value = 16.6), leg peak torque (F-value = 12.8), employment time (F-value = 12.8), muscle tightness (F-value = 7.6), marital status (F-value = 4.5), age (F-value = 3.9), shoulder work at the endurance level (F-value = 2.9), and Overall Wilks Lambda was 0.02. Seventy-eight subjects of the 85 subjects included in the analysis were classified correctly by the functions obtained from the discriminant analysis.

DISCUSSION

The 7 day prevalence of complaints in the neck and shoulder regions was high in the home care service group compared with reference groups (20), though not as high as that found in female assembly-line workers (5). Notably, nursing staff in home care service display more symptoms in the shoulder neck region than nursing staff at a hospital, the latter reporting the highest frequency of complaints in the lumbar region (32). Even though the work situations appear to be similar, the higher frequency of neck shoulder complaints in the home care service personnel group could be due to ergonomic factors such as more house cleaning chores and shopping. The psychosocial work situation in the home care service, with a higher degree of work without work-mates, could also be a factor causing more stress reactions in stress sensitive muscles (12, 29). A combination of ergonomic risk factors and a poor psychosocial environment has been found to increase the risk for neck and back pain (24).

A significant number of patients suffering from chronic pain cannot be assigned a diagnosis (25). Difficulties in assessing and quantifying the biomedical signs and symptoms that may be related to patient reports of pain are well recognised (27). Rosomoff et al. (25) consider physical findings to be estimates, soft data, leading to disputable conclusions. In order to make the influence of subjective prejudice of the examination as small and controlled as possible in the present study, the examination of all participants was carried out by the same physiotherapist (PT) without knowledge of their answers in the questionnaire. There was a relatively good agreement between reported complaints and the number of findings as the group with complaints had more findings (Tables II and III). Of course, even with similar reported complaints the underlying physiotherapy diagnosis differed. The major physiotherapy diagnoses were myalgia and unspecified neck pain. A lower frequency of tendinitis was found. We have not found any relevant studies containing a clinical investigation with which we can compare our results.

The home care personnel in this study were stronger and more enduring in the shoulder flexors than a reference group of physiotherapists and physiotherapy students, especially regarding the mechanical variable work (7, 11). The peak torque of the knee extensors did not display the same differences while work was higher than for a reference group (unpublished observations). The fact that the home care personnel were stronger in the upper extremity compared with a reference group is not surprising, considering that the work situation involves strength-demanding tasks for the upper extremity such as window-cleaning, carrying of shopping bags, lifting etc. These findings do not indicate a general necessity to introduce training programs with the primary intent to increase strength or endurance, especially since there was no correlation found between strength and symptoms. In fact a tendency (non-significant) for complaint reporters to have a higher mechanical strength was noted. The negative correlation between the signal amplitude ratio and mechanical performance found in this as well as in other of our studies indicates that working with a continuous contraction is uneconomic for the muscle. We believe that a high signal amplitude ratio is a sign of unhealthy muscle activity, leaving no room for natural microbreaks during repetitive work.

The signal amplitude ratio (SAR), i.e. the level of continuous contraction, in the shoulder flexors was relatively high, but there was a great interindividual difference. The signal amplitude ratio was similar to that of young physiotherapy students but somewhat higher than that of a group of healthy physiotherapists, 40–50 years of age (7, 11). Since there are individuals with a very low level of activity between contractions, we do not consider the signal amplitude ratio to be affected by the test procedure (7). This argument is also supported by the finding that the SAR of the leg is lower than that of the shoulder flexors even though the gravitational situation is similar. The higher SAR in the shoulder flexors than in the knee extensors could be explained by shoulder flexion being a more complicated movement involving both postural and rhythmic activity. The fact that the knee extensions were performed at a somewhat higher angular velocity could not explain this difference since our earlier studies of the shoulder flexors have shown that SAR will increase with increasing angular velocity (7). The positive correlation between the SAR of the shoulder flexors and the knee extensors could indicate individual patterns of activation and relaxation. Recently Johansson & Sojka (17) presented a hypothesis, implying that the stiffness regulation via the fusimotor-muscle-spindle system may be an important factor in occupational pain syndromes. They argue that metabolites produced by muscle contractions (e.g. static contractions during monotonous work) stimulate muscle group III and IV muscle afferents (26, 27, 28). These afferents activate static and dynamic gamma-motoneurons projecting to both homonymous and heteronymous muscles (1, 2) and it has been shown that reflex activation of gamma-motoneurons from group III and IV muscle afferents may be strong enough to influence the stretch sensitivity and discharges of both primary and secondary spindle afferents (2, 31). Increased activity in the primary muscle spindle afferents will enhance the reflex mediated stiffness of the muscles (16), which will lead to further production of metabolites in both homonymous and heteronymous muscles. This condition may then be perpetuated with less support from chemosensitive group III and IV afferents, due to the increased activity in the secondary spindle afferents (3, 31), which project back to the gamma-muscle-spindle system, and thus constitute a positive feedback loop (vicious circle) "built into" the reflex circuitry (3, 17, 31). This hypothesis suggests that increased muscle tension or stiffness are aetiological factors behind work-related muscle pain. If that were the case, one would perhaps expect to find that work-related myalgia in the neck-shoulder region is accompanied by a higher SAR, as was the case in the present study. There are also other reports indicating that elevated muscle activity and individual work techniques are related to muscle pain (8, 19, 30).

The total SAR was not lower in the subject group without reported symptoms, even though all the subjects but one with myalgia had a high SAR. An explanation of why certain persons had not developed symptoms even though they had a high SAR could be that static load or stress causes higher tension which precedes muscle pain. This is supported by the finding that non-complainers who had worked for a shorter time had a higher signal amplitude ratio than the non-complainer who had worked for more than ten years. The cluster analysis identified different subgroups in the material (cf. Table VI). Group A consisted of subjects employed for a long time with a low number of symptoms and a low SAR generally, a group which could be considered to be healthy workers. There was a group (group D) of young individuals with a low prevalence of complaints and with a high SAR. We suggest that these could either develop muscle pain symptoms later on unless they adjust their working technique and/or cope with other risk factors in the working environment. The Group B containing subjects in whom both subjective reports and clinical findings were high were also identified by the discriminant functions. A small Group C reporting intermediate prevalence of complaints, had a high SAR as well as many scores for muscle tightness. The fifth group (Group E) had many subjectively reported complaints but very few objective findings and exhibited a low SAR. This group had also worked for a short time as home care personnel. Since the group consisted of many individuals with more than one child, our suggestion is that this group is exposed to a higher amount of total work, thus having smaller margins.

One of the reasons why musculoskeletal problems are under debate is the existence of a spectrum of patients, from those with a good agreement between reported and observed complaints to those with a total disagreement between reports and observations. The present cluster analysis clearly points out the need to investigate the work-related complaints in a multivariate way which is likely to show that different groups exist within a relatively homogeneous occupational situation. Our observation should be of great importance in the designing of prevention and intervention programs. Thus, differentiated programs might have the best chances of success. Based on our observations of the SAR in the present study it would be reasonable to try to reduce the SAR in groups B, C and D with the purpose of decreasing the risk of complaints. We suggest that such training programs and ergonomic intervention should contain exercises aiming to reduce the periods with continuous muscle load, i.e. improve coordination, rather than to increase strength.

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