Long-term electromyographic activity in upper trapezius and low back muscles of women with moderate physical activity

Paul Jarle Mork and Rolf H. Westgaard
Norwegian University of Science and Technology, Trondheim, Norway
Submitted 17 February 2005; accepted in final form 1 April 2005

Mork, Paul Jarle, and Rolf H. Westgaard. Long-term electromyographic activity in upper trapezius and low back muscles of women with moderate physical activity. J Appl Physiol 99: 570–578, 2005. First published April 7, 2005; doi:10.1152/japplphysiol.00198.2005.—The habitual activity patterns of trapezius and postural back muscles (multifidus, iliocostalis, longissimus) of 23 female subjects with moderate physical activity were studied. Bilateral surface electromyographic (sEMG) recordings from start of work until bedtime were analyzed. The activity level was calibrated as percentage of root mean square-detected muscle activity at maximal voluntary contraction (EMG_{max}). Sixty-six previous trapezius recordings of women with moderate physical activity were included in some analyses to pursue the full range of variation in trapezius activity. Twenty-six of these were recorded twice, separated by 16–28 mo. Median activity level and duration of periods with sEMG activity of <0.5% EMG_{max} (“rest time”; only trapezius) and exceeding 2 (“burst time”), 10, 30, and 50% EMG_{max} was determined. The trapezius median activity level ranged from 0.6 to 8.8% EMG_{max}, postural muscles; habitual muscle activity; long-term recording

THERE IS SURPRISINGLY LITTLE INFORMATION available concerning the habitual activity patterns of muscles in everyday living, considering the large number of studies with surface electromyographic (sEMG) recording of muscle activity. Studies with long-term recordings exist, often with the aim of matching habitual muscle usage to muscle characteristics, such as the distribution of muscle fiber types. These studies have been performed on caged animals (9) as well as a few human studies (15, 23). Long-term sEMG recordings are common in occupational studies, often recording from upper trapezius or upper extremity muscles (e.g., Ref. 11). The explicit aim of these studies is to identify risk factors for muscular complaints. This favors data reduction procedures that seek population descriptors and preferably describe muscle activity pattern by as few variables (“risk indicators”) as possible.

Many studies in the occupational research tradition have noted the considerable individual differences in muscle activity patterns when performing apparently similar jobs or tasks (e.g., Refs. 1, 26). The variation in responses is usually perceived as a problem by masking the underlying, “true” muscle response and has triggered studies to determine, e.g., the number of subjects required to establish valid group mean responses (22). The interindividual differences in muscle usage are nevertheless of physiological interest as a general motor control issue and relating to muscle characteristics such as the percentage muscle fiber types and fiber size.

We have previously demonstrated considerable interindividual differences in upper trapezius activity pattern during controlled arm movement (36), contrasting consistent intra-individual responses in repeated recordings of the same arm movement (30). Large interindividual and consistent intra-individual responses in motor tasks point to considerable differences between individuals in their habitual control of the motor system. However, neither the interindividual variation in upper trapezius activity pattern nor the activity pattern of other postural muscles is well documented in long-term recordings. The aim of this study is to characterize the long-term, habitual activity patterns of trapezius and low back muscles of female subjects free of major work task-associated demands. Female subjects were selected because of our interest in shoulder pain development, which is more prominent for this gender. The results were compared with previous published results of muscle activity in upper and lower extremity muscles (15), with the anticipated outcome that the recordings of postural muscles, despite interindividual variation in responses, will show more sustained activity pattern than for the extremity muscles. Physiological implications of the different activity patterns of postural and extremity muscles are discussed.

METHODS

Subjects. Twenty-three female subjects (age 26–60 yr; mean ± SD: 44.7 ± 11.2 yr) were included in the study. They were employed as call-center operators in the sales department of a dairy company (n = 7), help-desk workers in a telecommunications firm (n = 9), and secretaries in a private safety company (n = 7). Their work duties involved use of computers and, for the call center, use of telephones. The work posture was predominantly seated. Body mass ranged from 55 to 86 kg (mean 66.5 ± 8.7 kg), and body mass index ranged from 19.5 to 32.6 kg/m² (mean 23.7 ± 2.9 kg/m²). Twenty of the subjects had children, 11 with children below 13 yr, and 5 with children below 6 yr.

In some of the analyses, the material was supplemented by previous recordings of trapezius activity pattern for female university secretar-
ies (n = 25), bank workers (n = 5), shop assistants in a small supermarket (n = 17), and health care workers (n = 19) to explore the full range of variation in sEMG activity patterns. The last two groups had a predominant standing posture at work. The age ranged from 19 to 64 yr (mean 44.0 ± 9.5 yr). Body mass ranged from 50 to 85 kg (mean 65.9 ± 7.9 kg), and body mass index ranged from 17.9 to 31.6 (mean 23.8 ± 2.8). The supplementary material has been analyzed previously to determine group results for median activity level and rest time (10); however, burst analysis (see sEMG analysis) and analyses with thresholds set for quantification of high-amplitude muscle activity were not performed. In the supplementary material, 26 subjects were invited to participate, but 20 declined. EMG recordings failed on eight subjects, whereas recordings failed on only the start and end side in six subjects for iliocostalis, two subjects for multifidus, and one subject for longissimus. Trapezius EMG recordings failed on both sides for four subjects, whereas three recordings failed on either the right (dominant) or left side. After removing incomplete recordings, the average recording time ranged from 13.3 to 13.8 h for the different muscles (Table 1), in which the work and leisure periods averaged 6.1 (range 4.9–6.9) and 7.7 h (range 4.6–10.6 h). Total recording time of the supplemental trapezius material ranged from 10.3 to 17.5 h (mean 14.0 h).

Calibration to maximal voluntary contraction. The subjects performed three isometric maximal voluntary contractions for upper trapezius and low back muscles both at the start and the end (i.e., start of work the next day) of the recording period. The highest EMG response, regardless of whether it was obtained at the beginning or the end of the recording, was used to normalize the EMG signal. For the upper trapezius, the maximal EMG response (EMGmax) was obtained from a posture with both arms 90° abducted in the scapular plane and resistance applied just proximal to the elbow joint. For the low back muscles, restricted back extension in a Roman chair was used to obtain EMGmax. Back extension was performed with hands behind the neck and straps around the chest to prevent trunk elevation above the horizontal, i.e., in line with the lower extremities. Maximal voluntary contractions were held for ~3 s, separated by 1-min pauses. Verbal encouragement was given by the experimenter for all calibration trials.

Intraclass correlation analysis and calculation of mean percentage difference between EMGmax obtained at the start and end of the recording period were used to assess the reliability of the EMGmax responses. Intraclass correlation coefficients ranged from 0.91 to 0.97, whereas mean percentage difference ranged from 4.4 to 7.4% (Table 1), indicating high reproducibility of the EMGmax response and unchanged calibration during the recording period. Body mass index was inversely correlated to EMGmax, with correlation coefficients ranging from 0.36 to 0.77 (0.001 < P < 0.05) for the different muscles.

sEMG analysis. Median and mean sEMG activity (% EMGmax), and time with sEMG activity of ≥2, >10, >30, and >50% EMGmax were determined. sEMG activity with amplitude of ≥2% EMGmax was also quantified by burst analysis, as described by Kern and coworkers (15). Outcome variables were number of bursts (bursts/h), mean burst duration (s), and mean burst amplitude (% EMGmax), additional to burst time (% of recording period). Further EMG variables in the complete trapezius material were duration of sEMG activity of <0.5% EMGmax (“rest time”), 90% of the amplitude distribution and the highest sEMG response, using a time resolution of 0.2 s. The sEMG responses were checked by visual inspection of an amplitude-time display of the sEMG recordings to ensure that obvious artifacts (singular, stand-alone events) were excluded. Such events

### Table 1. Recording time and EMGmax for low back muscles and upper trapezius

<table>
<thead>
<tr>
<th>Muscles</th>
<th>Recording Time, h</th>
<th>EMGmax (1st), µV</th>
<th>EMGmax (2nd), µV</th>
<th>Δ (1st–2nd), %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low back muscles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. multifidus (n = 19)</td>
<td>13.6±1.3</td>
<td>120±67</td>
<td>129±88</td>
<td>6.5±4.9</td>
</tr>
<tr>
<td>L. multifidus (n = 18)</td>
<td>13.4±1.4</td>
<td>115±68</td>
<td>115±86</td>
<td>7.4±4.9</td>
</tr>
<tr>
<td>R. longissimus (n = 18)</td>
<td>13.4±1.6</td>
<td>166±64</td>
<td>163±78</td>
<td>6.6±3.8</td>
</tr>
<tr>
<td>L. longissimus (n = 17)</td>
<td>13.8±1.2</td>
<td>132±47</td>
<td>132±51</td>
<td>6.9±3.5</td>
</tr>
<tr>
<td>R. iliocostalis (n = 15)</td>
<td>13.3±1.5</td>
<td>195±111</td>
<td>190±114</td>
<td>7.0±4.6</td>
</tr>
<tr>
<td>L. iliocostalis (n = 9)</td>
<td>13.5±1.0</td>
<td>169±99</td>
<td>177±99</td>
<td>4.4±1.2</td>
</tr>
<tr>
<td><strong>Upper trapezius</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. trapezius (n = 18)</td>
<td>13.5±1.7</td>
<td>1,209±618</td>
<td>1,184±644</td>
<td>5.1±3.1</td>
</tr>
<tr>
<td>L. trapezius (n = 17)</td>
<td>13.8±1.3</td>
<td>1,130±692</td>
<td>1,090±634</td>
<td>6.7±4.6</td>
</tr>
</tbody>
</table>

Values are means ± SD. EMG, electromyogram; EMGmax, maximal EMG recording. *Percentage difference from mean EMGmax, 1st and 2nd.
were eliminated in 12 recordings (8%). System noise (0.6–0.9 μV; Ref. 24) was subtracted before quantification of sEMG variables.

To allow use of independent-samples statistics, the sEMG responses were presented as the mean of the left and right side in the tables. If the recording on one side was lost, the successful recording was taken to represent the activity pattern of this muscle for that subject. The left and right sides are separately included in some of the figures to show the range of trapezius sEMG responses.

sEMG amplitude was also quantified during the calibration of inclinometers for posture recording (“uninformed rest”; Ref. 31). The subjects adopted a neutral standing posture with eyesight fixed at a far point at eye height for 45 s but received no instruction to relax their shoulders or otherwise modify their muscle activity level. This procedure was carried out both in the beginning and the end of the work period.

Subjective scoring of physical fatigue. The subjects scored their level of physical fatigue on Borg’s scale (3) on an hourly basis during daytime activity. Average and maximum scores during work and leisure were used to assess the level of subjective physical fatigue.

Statistical analyses. A Shapiro-Wilk W-test for normality was performed on all dependent variables before statistical analysis. Nineteen of 32 EMG variables (8 EMG variables in 4 muscles) were found to be nonnormally distributed. Nonparametric statistical methods were therefore used in the analyses. All comparisons were performed two tailed, and the significance level was set to \( P < 0.05 \). Data are reported as means ± SD unless otherwise stated.

One-way ANOVA on ranks (Kruskal-Wallis) with a Kruskal-Wallis z-score post hoc test was used to test the hypothesis that EMG activity did not differ between muscles during daytime activity. A two-way random intraclass correlation analysis was used to assess agreement between EMGmax obtained at the start and end of the recording period and to assess the agreement between repeated recordings of work and uninformed rest in upper trapezius. Linear regression coefficients and Spearman’s rho were used for other correlation analyses.

RESULTS

Physical activity level of subjects. The level of physical exertion was monitored by recording heart rate and collecting hourly scores of fatigue by Borg scale. Heart rate was 81 ± 9 beats/min during work and 83 ± 9 beats/min in the leisure period. Mean fatigue scores for the work and leisure periods were 1.1 and 1.6 on the Borg scale, anchored as “very weak” at 1 and “weak” at 2. Mean value for the hour with highest fatigue score was 1.9 (work) and 2.8 (leisure), usually scored toward the end of the work period and late in the evening. Corresponding values for the supplementary material of trapezius recordings were, for heart rate, 84 ± 9 (work) and 79 ± 7 beats/min (leisure). Mean fatigue scores were 1.1 (work) and 1.9 (leisure); mean values of highest fatigue score were 1.8 (work) and 2.7 (leisure). There were no significant correlations between fatigue score and heart rate or EMG variables (\( r < 0.2 \) for all combinations of observation periods and physiological variables).

Daytime sEMG activity of postural muscles. Table 2 shows daytime sEMG activity for trapezius and low back muscles. Group mean values for the six EMG variables, SD, and range of responses are presented. Similar activity levels were found for all muscles, except somewhat less activity was indicated for iliocostalis. This trend was significant for mean burst duration (compared with all other muscles) and mean activity (vs. multifidus). Burst time was indicated significant by the multivariate analysis, but post hoc analyses did not show significant differences between groups. However, unitary comparisons indicate that burst time for iliocostalis was less than for the other muscles (\( P < 0.05 \) for all unitary comparisons). Another noted feature in Table 2 is the large interindividual variation in sEMG responses, whatever sEMG variable is used. There was no association between sEMG variables and calibration responses (i.e., EMGmax).

The overall duration of periods with sEMG amplitude exceeding 10, 30, and 50% EMGmax is shown in Table 3. Clear differences between muscles with respect to these variables were found; the duration of periods with high contraction amplitude (>50% EMGmax) was much longer for multifidus than trapezius, with iliocostalis and longissimus showing intermediate responses. The group mean duration of periods with sEMG amplitude exceeding 50% EMGmax corresponds to 0.7 s/h or ~12 s for a daytime period of 17 h for trapezius. The differences between groups are significant for all muscle activity levels.

Table 3. EMG time, as percentage of total recording time, above 10, 30, and 50% EMGmax for low back muscles and upper trapezius.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>&gt;10% EMGmax (%)</th>
<th>&gt;30% EMGmax (%)</th>
<th>&gt;50% EMGmax (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifidus</td>
<td>11.5±7.3 (2.7–28)</td>
<td>1.1±1.2 (0.02–4.4)</td>
<td>0.30±0.40 (0.01–1.2)</td>
</tr>
<tr>
<td>Longissimus</td>
<td>8.3±4.4 (1.1–15)</td>
<td>0.3±0.5 (0.02–2.0)</td>
<td>0.10±0.40 (0.01–1.6)</td>
</tr>
<tr>
<td>Iliocostalis</td>
<td>3.8±3.0 (0.4–11)</td>
<td>0.2±0.2 (0.01–0.9)</td>
<td>0.10±0.10 (0.0–0.4)</td>
</tr>
<tr>
<td>Trapezius</td>
<td>5.6±5.1 (1.3–20)</td>
<td>0.2±0.4 (0.1–1.5)</td>
<td>0.02±0.02 (0.0–0.8)</td>
</tr>
</tbody>
</table>

Values are means ± SD of right and left sides, with range in parentheses. Post hoc tests: *\( P < 0.001 \) multifidus different from iliocostalis and trapezius; †\( P < 0.004 \) multifidus different from iliocostalis and trapezius; ‡\( P < 0.001 \) multifidus different from trapezius.
corresponding duration for multifidus was 11 s/h or ~3 min for the full daytime period.

The trapezius recordings of the present study were supplemented with 113 whole-day recordings from 66 subjects in a previous study (10). The group mean value of the median daytime activity level was 3.0 ± 1.6% EMG<sub>max</sub> (range 0.8–7.1% EMG<sub>max</sub>), which is higher than in the present study (P = 0.01). Subjects with predominant seated and standing postures at work had similar median daytime activity levels (group mean values 3.1 and 2.6% EMG<sub>max</sub>, respectively).

The distributions of median sEMG activity level, burst time, and rest time for the complete material are shown by histograms in Fig. 1, A–C, with left and right trapezius recordings separately included. Scatterplots of responses for the dominant vs. nondominant side are shown in Fig. 1, D–F. Regression line and line of identity are included in the scatterplots. Trapezius muscle activity was mostly symmetrical as measured by the three sEMG variables, except for a markedly higher median sEMG activity for the dominant trapezius in a few subjects.

Interindividual variation in sEMG responses was large, regard-
less of method used for quantification. Finally, scatterplots showing interrelationships between the three sEMG variables are presented in Fig. 1, G–I. In case of median EMG level vs. burst time and rest time, the relationships are clearly curvilinear: median EMG level vary considerably for similar, high burst time. Burst time and rest time vary considerably for the same low median EMG level.

Figure 2 shows scatterplots of mean sEMG amplitude for trapezius and low back muscles when adopting a neutral standing posture (uninformed rest) before and after the work recording. The consistency of the test responses motivated us to reexamine a subgroup of subjects in the supplementary trapezius material that were recorded twice with a separation of ~2 yr. The first recording included only the work period (37), and trapezius sEMG responses for the two work periods were compared (Fig. 3, A–C). The scatterplots show highly consistent responses, despite the separation in time and likely differences in work tasks performed: there was no attempt to control movements or work tasks during the recordings. The uninformed rest responses were also very consistent, similar to repeated recordings of uninformed rest the same day (Fig. 3D).

In view of the short duration of periods with trapezius sEMG activity exceeding 50% EMGmax, the interval (0.2-s duration) with the highest sEMG response and the 90th percentile of the cumulative distribution for sEMG activity were determined (Fig. 4). Highest sEMG amplitude ranged from 38 to 113% EMGmax; 7% of the recordings did not present time intervals (0.2-s duration) with sEMG amplitude of ≥50% EMGmax (Fig. 4A). Group mean value for the 90th percentile of the amplitude distribution curve was 10.4% EMGmax (range 1.7–28.8% EMGmax; Fig. 4B). Corresponding mean values for the low back muscles were 11% (multifidus), 9.5% (longissimus), and 5.7% EMGmax (iliocostalis).

**DISCUSSION**

This study provides a comprehensive description of habitual daytime activity patterns for the upper trapezius and postural muscles in the low back of female subjects with moderate physical demands. The analyses of the sEMG activity pattern, focusing the duration of periods exceeding defined thresholds, allow estimates of silent periods for low-threshold motor units and the duration of active periods for motor units with higher recruitment thresholds.

Figure 5 presents results from this study and presumed comparable results of recordings from upper (first dorsal interossius, biceps brachii) and lower extremity (medial and lateral vastus) muscles of moderately active female students (15). Burst time was substantially different between muscles: mean values were 40–50% of the recording time for trapezius, longissimus, and multifidus, ~20% for upper extremity muscles, and ~15% for lower extremity muscles. Mean burst amplitude was 4–5% EMGmax for postural, 7–8% EMGmax for upper extremity, and ~20% EMGmax for lower extremity muscles. Motor units with relatively high recruitment threshold (e.g., >10% EMGmax) may thus be active for longer periods of time in case of the lower extremity muscles than for the postural low back muscles and trapezius. The mean burst

![Fig. 2. Muscle activity in multifidus (A), longissimus (B), iliocostalis (C), and trapezius (D) obtained in standing, nominal resting posture (“uninformed rest”). Scatterplots of mean sEMG amplitude at the beginning and end of the work period are shown. Linear regression and line of identity are shown.](http://www.jap.org/...)

*J Appl Physiol* • Vol 99 • August 2005 • www.jap.org
amplitude of trapezius is markedly lower than for all the other muscles and quite invariant, indicating that a select population of motor units is active during bursts for this muscle. The activity patterns of the four postural muscles are clearly distinguished from upper and lower extremity muscles, thereby verifying the introductory assumption.

Three findings stand out in this description of whole-day activity patterns of the four postural muscles; first, the interindividual differences in sEMG activity pattern were large, ranging from near inactivity to relatively high activity levels. Second, repeated recordings indicate that both resting-level muscle activity (“muscle tonus”) and overall daytime muscle activity were relatively invariant for each subject. Third, periods of moderately high sEMG activity were of very short duration, especially for trapezius. It is tempting to speculate that the large variation in muscle activity patterns is a reflection of the similar variation in fiber-type composition: an autopsy study of the trapezius in five females found the percentage of type I fibers ranged from 45 to 73% and type IIB fibers ranged from 2 to 25% at a site corresponding to the sEMG electrode location (18). However, it is estimated that genetic and environmental factors contribute equally to the variation in fiber type proportions (28). The fiber-type composition of trapezius, low back, and extremity muscles is surprisingly similar, both with respect to mean percentage fiber types and the interindividual variation in fiber types for different muscles (4, 13, 14, 29). The mixed fiber-type composition of the postural muscles may be understood by reference to the low burst amplitude: only a moderate fraction of the force-generating capacity for these muscles need to consist of type I motor units to sustain the long periods of activity.

Rest time was quantified only for trapezius due to low calibration responses for the low back muscles. The detection level of 0.5% EMG_{max} corresponds to the sEMG contribution of two to three motor units underneath the sEMG electrode (33). Burst amplitude of 2–5% EMG_{max} is estimated to represent the sEMG contribution of 40–70 motor units (33), with numbers increasing if contributing motor units are located away from the sEMG electrode. Thus rest time represents periods of rest and recovery for the population of upper trapezius motor units detected by the sEMG electrode, whereas burst time represents duration of sustained activity of at least some of the low-threshold motor units. Periods of motor unit silence occur, but such periods seem to be of short duration if sEMG amplitude is substantially higher than the motor unit recruitment threshold (34).

Burst time ranged from <10 to >80% of the daytime recording period and was similar for trapezius, multifidus, and longissimus. This compares to type I motor units in rat soleus muscle, which were active for 22–35% of the recording period (8). Many motor units in postural muscles are likely to have a duty time substantially longer than those observed in the rat, even after adjusting for reduced activity during sleep (24). Thus conditions that may cause type I motor unit exhaustion and thereby development of “ragged red fibers” exist (7, 17).

Putative type IIB motor units in rat leg muscles were active for 0.04–0.22% of time over 24 h (8). Time periods with sEMG amplitude >50% EMG_{max} were of similar duration for
the low back muscles but were shorter or nonexistent in case of trapezius. The question may thus be raised whether human muscle fibers tolerate day-long periods of inactivity. Studies of membrane properties in controlled stimulation of inactive and denervated rat and baboon muscle fibers provide a partial answer. Extrajunctional acetylcholine sensitivity in nerve-blocked baboon lumbrical muscle fibers was reduced after \( \sim 1 \) wk of stimulation with 500 pulses (5 pulses/s stimuli for a total duration of 100 s) but not with 50 pulses (5 pulses/s for 10 s) once every 24 h (6). Denervated rat muscle fibers showed reduced acetylcholine sensitivity after 2 wk of stimulation with 100 pulses (10 Hz for 10 s) every 5.5 h but not with 100 pulses at 12-h intervals (19). Thus a few seconds of activity per 24 h seem sufficient for maintenance of muscle membrane structure both for the rat and the baboon. Few firings of high-threshold motor units in postural muscles of females may explain the smaller cross-sectional area of type II relative to type I muscle fibers (18, 29).

The few or missing periods of moderately high sEMG amplitude may seem at odds with motor unit recruitment thresholds up to 80% maximal voluntary contraction for proximal extremity muscles (5, 16) and for sEMG amplitudes exceeding 50% EMG\(_{\text{max}}\) in case of trapezius motor units (Ref. 35 and unpublished observations). However, a considerable increase in firing rates of trapezius motor units is observed even in relatively slow ramp contractions (35), whereas firing rates tend to stay low in sustained contractions (32). More motor units are therefore required to generate the same sEMG amplitude, resulting in an apparent reduction of recruitment threshold. This firing behavior is in contrast to first dorsal interosseous (FDI), biceps brachii, vastus medialis, and vastus lateralis of female subjects is from Kern et al. (15).
interosseus motor units, which have firing patterns that closely mimic the sEMG activity profile both in sustained contractions and in contractions with rapid amplitude modulation (35).

Monster et al. (23) found that muscles with the highest proportion of type I fibers had the longest daily duration of muscle activity in most comparisons, but this finding was neither corroborated by Kern et al. (15) nor is evident from Fig. 5 and known fiber type proportions of these muscles. The discrepant results may be due to differences in calibration procedures since the duration of measurements by Monster and coworkers were based on muscle activity higher than 8% of the 90th percentile of the amplitude distribution. The effective threshold for detecting muscle activity by the Monster et al. criterion would vary between 0.14 and 2.3% EMG max for trapezius. There will also be systematic variation between muscles.

The year-long consistency of the daytime sEMG responses was a surprise. We speculate that the long recording period average out short-term, task-based variations in activity patterns. Also, the consistency of responses is probably helped by this being work recordings of subjects in predominant standing postures with little or no demands of high force exertions or working in constrained postures. The long-term sEMG recordings may thus be a measure of the habitual muscle usage of subjects, their motor habit: a subject-specific muscle activity pattern that is also a characteristic when the standardized resting posture is adopted.

The profound differences in muscle activity pattern are likely to influence the ability of muscle fibers to sustain contractions, also within the same fiber-type population. The muscle metabolic apparatus is very adaptable, increasing the number and volume of muscle fiber mitochondria and capillary density with exercise and reducing metabolic capacity when the muscles return to the nontrained state (27). The marked differences in muscle activity patterns seem stable over periods of several years; thus motor unit adaptation to exercise may represent an individual characteristic right through to adolescence. If so, group-based quantification of muscle activity patterns may not be well suited to show muscle fiber overexertion and risk of muscle pain when tasks are performed that require moderate physical activity.

In conclusion, the activity pattern of postural low back muscles and trapezius show considerable interindividual variation; however, they remain distinctly different from the activity patterns of upper and lower extremity muscles reported by others (15). We speculate that the observed interindividual variation in long-term recordings of muscle activity pattern represents habitual differences in postural motor programming: their motor habit.

GRANTS
This study was supported by the Norwegian Research Council.

REFERENCES
30. Vasseljen O, Johansen BM, and Westgaard RH. The effect of pain reduction on perceived tension and EMG-recorded trapezius muscle ac-


