Prevalence of musculoskeletal symptoms among aluminium workers

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The aim of this study was to determine the prevalence of musculoskeletal symptoms (MSS) in workers in the aluminium industry, and to test the relationship with work by using the duration of employment as a measure of exposure. A total of 5654 workers (92%) answered a questionnaire. Operators, who were more exposed to physically demanding work, showed a greater incidence of MSS than did office workers. Among operators, the duration of employment was significantly correlated with MSS in nine out of ten areas of the body, when adjusted by multiple regression analyses for age, gender, height, weight, smoking and physical activity. Among office workers this relationship was weaker and was significant only for neck and lower back areas. The higher prevalence of MSS among operators and the association between their duration of employment and MSS suggests that a higher risk of MSS is related to the working environment.

Key words: Epidemiology; exposure; gender; manual work; operators; questionnaire; risk factors; survey.

INTRODUCTION

Musculoskeletal symptoms (MSS) are very common in industrialized countries, and result in pain and suffering among individuals and economic consequences for governments and employers.1–4 Several studies have reported associations between MSS and both adverse psychosocial and physical factors in the working environment.5–8 The proportion of work-related MSS which could be avoided by achieving a safe and healthy work environment is difficult to estimate due to the highly multifactorial aetiology. The proportion has been estimated to be between 30 and 40% in Nordic countries.9

MSS frequently causes disability and increased sick leave.10 The requirement for disability pensions and sick leave caused by musculoskeletal diseases varies in different occupations and tends to be higher among manual workers than among office workers.11 The high incidence of sick leave in certain occupations may be caused both by high occupation-specific morbidity and by factors associated with the effects of disease. These include difficulties in meeting requirements for physical fitness and lack of control over both the work situation and the opportunity to cope with it.12,13

Work in the aluminium industry is physically demanding. Many operators work in 'pot-rooms' and 'cast-houses', where well-known physical risk factors include awkward working postures, static-load lifting and carrying,6,14–16 In addition, psychosocial factors such as decision latitude, job satisfaction and social support may also influence the prevalence of MSS.16 A previous survey has indicated a high prevalence of MSS in aluminium plants, and sick leave caused by the condition.17

MSS are multifactorial in nature, and although occupational risk factors are thought to contribute to MSS, many other factors are also known or suspected to be causative.18 Preventing MSS in a working population requires evaluating the possible occupation-specific factors as well as individual characteristics and determin-
ing their association with MSS. Age, gender, height, weight, smoking status and physical activity may influence the occurrence of MSS and are controlled for in several studies. Understanding how individual variables can alter the risk presented by a specific work environment can guide the selection of possible intervention measures.

As a baseline for intervention to improve the working environment, and to prevent and reduce MSS and consequent sick leave among people employed in the aluminium industry, a cross-sectional study was performed. This examined the prevalence of MSS and the relationship with individual characteristics and the working environment.

The first aim of this study was to determine the total prevalence of self-reported MSS among male and female manual operators and office workers in the Norwegian aluminium industry. Another aim was to estimate the association between MSS and the duration of employment as an exposure variable, adjusted for individual characteristics.

PARTICIPANTS AND METHODS

Participants

In 1998, 6156 people working at the eight aluminium smelting plants in Norway were invited to answer a self-administered questionnaire about MSS and working conditions. To compare two categories of worker who undertook different physical work, but with comparable socio-economic status, they were divided into three groups (operators, office workers and managers). In this study operators and office workers were chosen. The operators’ tasks consisted of various types of manual work such as cast-house and pot-room production, cleaning and repairing.

The questionnaire

The questionnaire that was developed was pre-tested, refined and approved by the health and safety committee in each plant. It was completed anonymously, but a code was included to enable matching with future surveys among the same individuals. The workers gave written consent before participating. Physiotherapists distributed the questionnaire at special meetings held at the plants.

This study was based on data from questions on job title (operator, manager or office worker), occurrence of MSS in the past 12 months (1-year prevalence), and the duration of employment at the plant. Duration of employment has been used to investigate exposure–response associations in the establishment of links between occupational hazards and disease in several epidemiological studies. The duration of employment at the plant was used as an indirect measure of the total work-related exposure to risk factors for MSS. Questions not related to work included age, gender, height, weight, smoking status and physical activity outside work.

The occurrence of MSS was recorded according to a modification of the Standardized Nordic Questionnaire (SNQ) for the analysis of MSS. Most questions about MSS were phrased as follows. ‘Have you, at any time during the last 12 months, had trouble (ache, pain, discomfort) in [body area]?’ The list included the head, neck, shoulders, elbows, hands, upper back, lower back, hips, knees and feet. Instead of using clear cut alternatives for the answers, a five-point scale ranging from ‘never’ to ‘very often’ was used. ‘Head’ was added to the nine areas of the body as defined in the SNQ.

Physical activity was assessed by total, weekly, physical leisure activity (walking, jogging, aerobics, cycling, swimming and ball playing), of less than 2 h duration, from 2–5 h, or more than 5 h. Smoking was divided into ‘current smoking’ or ‘non-smoking’.

Statistical analyses

Differences in the prevalence of MSS for each area of the body, for both men and women, and for each job category were analysed by using $t$ tests. Odds ratios and 95% confidence intervals were calculated by categorizing MSS into ‘often’ or ‘very often’ (scoring 4 and 5, respectively) and ‘never’, ‘seldom’ or ‘sometimes’ (scoring 1, 2 and 3, respectively).

Pearson’s correlation coefficients were used to assess the relationships between MSS and age, MSS and duration of employment, and age and duration of employment. Since these variables were correlated, a multivariate regression analysis was carried out separately for each area of the body, with an MSS score as a dependent variable and duration of employment at the plant, age, gender, height, weight, smoking status and physical activity as the independent variables. The analyses were performed separately for operators and office workers. The analyses were performed using the SPSS 8.0 computer package. The significance limit was set at $P = 0.05$.

RESULTS

The questionnaire was completed by 5654 workers (92%) (age range 18–69 years). Of these, 3761 were operators, 1139 office workers and 469 managers. Eighty-six percent were men and 14% were women. The mean age was 40 years (SD = 11). The mean duration of employment at the plant was 16 years (SD = 9.9, range 0–48), and 525 (9%) had been working at the plant for more than 30 years. The age and duration of employment among operators and office workers are shown in Table 1.

One-year prevalence of MSS

A total of 93% of the operators and office workers had experienced pain, reduced mobility or other discomfort in one or more of the ten defined areas of the body during the past 12 months; 49% answered that they had MSS often or very often in one or more body area. More
Table 1. Age and duration of employment among operators and office workers in the aluminium industry

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Duration of employment (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Operators (n=3761)</td>
<td>39</td>
</tr>
<tr>
<td>Office workers (n=1139)</td>
<td>44</td>
</tr>
<tr>
<td>Men</td>
<td></td>
</tr>
<tr>
<td>Operators (n=3205)</td>
<td>39</td>
</tr>
<tr>
<td>Office workers (n=796)</td>
<td>44</td>
</tr>
<tr>
<td>Women</td>
<td></td>
</tr>
<tr>
<td>Operators (n=412)</td>
<td>39</td>
</tr>
<tr>
<td>Office workers (n=299)</td>
<td>42</td>
</tr>
</tbody>
</table>

Figure 1. Musculoskeletal symptoms (MSS) in the past 12 months among operators and office workers in the aluminium industry (n=4868).

women (56%) than men (48%) said that they had MSS often or very often in one or more body areas (P<0.001). The most common MSS were in the neck (68%), shoulders (67%) and lower back (76%) (Fig. 1).

The prevalence rates of MSS among operators and office workers are shown in Fig. 2. Symptoms in the lower back, elbows, hands, knees and feet were reported significantly more often among operators than among office workers (Table 2).

Among operators, women reported significantly more MSS than did men in all areas of the body except the knees. Women operators most frequently reported MSS in the neck (30%) and shoulders (33%), and men operators in the lower back (24%) (Fig. 3).

The operators' group was employed in many different types of work. Some of the jobs were predominantly carried out by male workers and others predominantly by female workers. To compare the jobs of male and female operators as equally as possible, those from cast-houses and pot-rooms were analysed separately. In cast-houses and pot-rooms, men and women mostly perform the same tasks, and these differ from those of the other departments where operators work. The differences in MSS between female and male operators were found to be greatest for the head, neck, shoulders, hands, and hip areas (Table 3).

Correlation analysis showed that the prevalence of MSS in all areas of the body increased with age (P<0.001 for all areas of the body). The areas with the strongest correlation with age were the neck (r = 0.18), shoulders (r = 0.21), elbows (r = 0.20) and hips (r = 0.23). The prevalence also increased with the duration of employment (P<0.001 for all areas of the body). Age and duration of employment correlated strongly (r = 0.78), and multivariate analysis was therefore performed.

Risk factors for MSS

In the multivariate regression analysis, including age of the total group of operators, the duration of employment was significantly correlated with MSS in all areas of the body.
MSS among operators than among office workers. The DISCUSSION back (>0.05), but not with the other areas of the body since the prevalence of MSS among them was correlated

This study demonstrated a higher 1-year prevalence of MSS in 93% of the whole group of aluminium workers was high. In population surveys, the 1-year prevalence rates of musculoskeletal complaints were 85% in Norway\(^1\) and 69% in Denmark.\(^2\) A study among construction workers in Sweden found a prevalence of 92%.\(^2\) However, the questionnaires used for the surveys have differing ‘cut-off’ points for determining frequency, intensity and duration of symptoms, which therefore makes comparison difficult.\(^25\) Medical examination may diagnose part of this prevalence as disease. Different variations of normal conditions will be included in self-reported MSS based on these questionnaires. However, studies support the observation that MSS are most frequent in the neck, shoulders and lower back.\(^1,2\) In this present study, manual workers had a higher prevalence of MSS than did office workers, and this supports the findings of other authors.\(^11,26,27\)

The duration of employment was used in this study as a substitute measurement for work-related exposures. These exposures include both psychosocial and physical risk factors, but based on this study it was not possible to differentiate between their importance. Duration of employment was strongly correlated with age, which again is known to be associated with an increasing prevalence of MSS.\(^1,2,11,26,27\) The association between MSS and the duration of employment among operators remained significant for all areas of the body, except the elbows, in the multivariate regression analysis when adjusted for age. Only a few studies have found that duration of employment contributes to MSS when adjusted for age.\(^28,29\) While other studies did not show a similar relationship.\(^24,30,31\) If an indirect measure, such as duration of employment, is to accurately represent total or cumulative exposure, some conditions must be met: (1) the exposure intensity must be relatively constant throughout the work site; (2) the exposure intensity must have remained constant over time; and (3) work assignments into higher or lower levels of exposure intensity must not be made based on seniority.\(^32\) In addition, variation between the age of workers and the duration of their employment must be present, and the sample size has to be sufficiently large to reflect this.

Similar to other studies, this study found the prevalence of MSS to be generally higher among women than men.\(^1,2,4,11,23,33,34\) It has been suggested that this difference results from the fact that the occupational composition of the groups may differ between male and female employees. However, in the present study these gender differences were still present when operators were selected from pot-rooms and cast-houses only, where the jobs of men and women were supposed to be more comparable. This study did not analyse the specific work-related risk factors among male and female operators, and the differences between men and women may therefore reflect the fact that women are exposed to different physical risk factors.\(^34\) Firstly, the higher association between the duration of employment and

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### Table 3. Odds ratios and 95% confidence interval (CI) for musculoskeletal symptoms among female operators (n=178) versus male operators (n=1709) in cast-houses and pot-rooms

<table>
<thead>
<tr>
<th>Area of the body</th>
<th>Odds ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>2.8</td>
<td>1.8-4.3</td>
</tr>
<tr>
<td>Neck</td>
<td>1.9</td>
<td>1.3-2.7</td>
</tr>
<tr>
<td>Shoulders</td>
<td>1.4</td>
<td>1.0-2.0</td>
</tr>
<tr>
<td>Elbows</td>
<td>1.3</td>
<td>0.7-2.1</td>
</tr>
<tr>
<td>Hands</td>
<td>1.8</td>
<td>1.2-2.7</td>
</tr>
<tr>
<td>Upper back</td>
<td>1.1</td>
<td>0.6-2.0</td>
</tr>
<tr>
<td>Lower back</td>
<td>1.1</td>
<td>0.8-1.6</td>
</tr>
<tr>
<td>Hips</td>
<td>1.6</td>
<td>0.9-2.7</td>
</tr>
<tr>
<td>Knees</td>
<td>0.7</td>
<td>0.4-1.2</td>
</tr>
<tr>
<td>Feet</td>
<td>1.3</td>
<td>0.8-2.2</td>
</tr>
</tbody>
</table>

body except the elbows (Table 4). This means that duration of employment was related to MSS even when comparing workers of the same age. Significant relationships were also found between the other independent variables in the analysis and MSS in several areas of the body. Smoking correlated with MSS in the neck, shoulders and lower back. Height correlated negatively with MSS in the head, shoulders, hands and feet. Weight correlated with MSS in the head, shoulders, elbows, hands, lower back, knees and feet. Physical activity correlated negatively with MSS in the head, neck, hands, upper back and lower back. The percentage of total variance in MSS that could be explained by all the independent variables ranged from 2% in the head and upper back, to 8% in the shoulders and hips.

Since female operators had significantly higher rates of MSS in most areas of the body, analyses were performed separately for men and women. Among both male and female operators, the duration of employment correlated with MSS for most areas of the body.

The multivariate regression analyses among office workers showed that the duration of employment was significantly correlated with MSS in the neck and lower back \((P<0.05)\), but not with the other areas of the body (Table 5).

### DISCUSSION

This study demonstrated a higher 1-year prevalence of MSS among operators than among office workers. The operators are more exposed to physical risk factors, and since the prevalence of MSS among them was correlated with the duration of employment, the findings indicate a relationship between MSS and work.

Compared with other studies, the 1-year prevalence of MSS in 93% of the whole group of aluminium workers was high. In population surveys, the 1-year prevalence rates of musculoskeletal complaints were 85% in Norway\(^1\) and 69% in Denmark.\(^2\) A study among construction workers in Sweden found a prevalence of 92%.\(^2\) However, the questionnaires used for the surveys have differing ‘cut-off’ points for determining frequency, intensity and duration of symptoms, which therefore makes comparison difficult.\(^25\) Medical examination may diagnose part of this prevalence as disease. Different variations of normal conditions will be included in self-reported MSS based on these questionnaires. However, studies support the observation that MSS are most frequent in the neck, shoulders and lower back.\(^1,2\) In this present study, manual workers had a higher prevalence of MSS than did office workers, and this supports the findings of other authors.\(^11,26,27\)

The duration of employment was used in this study as a substitute measurement for work-related exposures. These exposures include both psychosocial and physical risk factors, but based on this study it was not possible to differentiate between their importance. Duration of employment was strongly correlated with age, which again is known to be associated with an increasing prevalence of MSS.\(^1,2,11,26,27\) The association between MSS and the duration of employment among operators remained significant for all areas of the body, except the elbows, in the multivariate regression analysis when adjusted for age. Only a few studies have found that duration of employment contributes to MSS when adjusted for age.\(^28,29\) While other studies did not show a similar relationship.\(^24,30,31\) If an indirect measure, such as duration of employment, is to accurately represent total or cumulative exposure, some conditions must be met: (1) the exposure intensity must be relatively constant throughout the work site; (2) the exposure intensity must have remained constant over time; and (3) work assignments into higher or lower levels of exposure intensity must not be made based on seniority.\(^32\) In addition, variation between the age of workers and the duration of their employment must be present, and the sample size has to be sufficiently large to reflect this.

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Table 4. Association between musculoskeletal symptoms and duration of employment, gender, smoking, weight, height and physical activity among operators: multiple regression analyses with body part as the dependent variable (n = 3761)

<table>
<thead>
<tr>
<th>Area of the body</th>
<th>Duration of employment</th>
<th>Age</th>
<th>Gendera</th>
<th>Smoking</th>
<th>Height</th>
<th>Weight</th>
<th>Physical activity</th>
<th>Adjusted r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>0.13 &lt; 0.001</td>
<td>-0.02</td>
<td>0.45</td>
<td>0.08 &lt; 0.001</td>
<td>0.00</td>
<td>0.86</td>
<td>-0.06 0.006</td>
<td>0.04 0.038 &lt; 0.04 0.011 0.02</td>
</tr>
<tr>
<td>Neck</td>
<td>0.16 &lt; 0.001</td>
<td>0.05  0.06</td>
<td>0.12 &lt; 0.001</td>
<td>0.04 0.009</td>
<td>-0.04 0.10</td>
<td>0.01 0.55</td>
<td>-0.04 0.032 0.06</td>
<td></td>
</tr>
<tr>
<td>Shoulder</td>
<td>0.10 &lt; 0.001</td>
<td>0.01  0.05</td>
<td>0.06 &lt; 0.001</td>
<td>0.06 &lt; 0.001</td>
<td>-0.08 &lt; 0.001</td>
<td>0.06 0.007</td>
<td>0.01 0.52 0.08</td>
<td></td>
</tr>
<tr>
<td>Elbows</td>
<td>0.05 0.08</td>
<td>0.02  &lt; 0.001</td>
<td>0.03 0.20</td>
<td>0.01 0.68 0.06 0.06</td>
<td>0.05 0.010 &lt; 0.01 0.53 0.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hands</td>
<td>0.07 0.017</td>
<td>0.04  0.13</td>
<td>0.09 &lt; 0.001</td>
<td>0.03 0.09</td>
<td>-0.10 &lt; 0.001</td>
<td>0.06 0.004 -0.04 0.037 0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper back</td>
<td>0.11 &lt; 0.001</td>
<td>0.01  0.71</td>
<td>0.05 0.009</td>
<td>0.02 0.16</td>
<td>0.00 0.85 0.00 -0.01 0.51 &lt; 0.04 0.019 0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower back</td>
<td>0.19 &lt; 0.001</td>
<td>0.00  0.50</td>
<td>0.07 &lt; 0.001</td>
<td>0.04 0.041</td>
<td>0.02 0.38 0.06 0.003 &lt; 0.04 0.025 0.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hips</td>
<td>0.07 0.011</td>
<td>0.19  &lt; 0.001</td>
<td>0.14 0.001</td>
<td>0.01 0.72 0.00 0.94 0.02 0.26 &lt; 0.02 0.34 0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knees</td>
<td>0.14 &lt; 0.001</td>
<td>0.02  0.57</td>
<td>0.02 0.45</td>
<td>0.01 0.68 0.01 0.74</td>
<td>0.10 &lt; 0.001</td>
<td>0.00 0.84 0.03</td>
<td></td>
<td></td>
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<tr>
<td>Feet</td>
<td>0.06 0.031</td>
<td>0.07  0.018</td>
<td>0.04 0.033</td>
<td>0.01 0.46</td>
<td>-0.08 0.001 0.11 &lt; 0.001 &lt; 0.01 0.41 0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aMale = 1, female = 2.

Several other studies have also found an association between smoking and MSS in the neck and shoulders,38-40 and between smoking and lower back pain41 as found in the present study.

In this study being overweight and of short stature seem to be risk factors for MSS in most areas of the body, and other studies present similar findings.42,43 The strong associations between height and MSS in the neck region of office workers and suggested that workplace design was ergonomically better adapted for taller workers. The strong association in this study between weight and MSS in the knees is also in agreement with the results of other studies, and suggests weight as a risk factor, explained by development of arthrosis of the knee.34,44 The present study also found an association between weight and MSS in the lower back. This has also been found in some previous studies.38

In the multivariate analysis of MSS and individual factors, the variance explained (adjusted r²) was relatively low. The causes of MSS are highly multifactorial, and the present analysis reflects only a few. Furthermore, the duration of employment is a highly indirect measure of cumulative exposure,37 and a more valid and detailed measure of exposure would probably yield higher explained variance.
In our study, the presence of physical activity was related to a lower prevalence of MSS in the head, neck, hands, upper back and lower back areas. The contribution of physical activity to MSS was small, compared with the duration of employment and gender. Various studies have shown that physical activity affects MSS. Others have shown either no or only a weak association between leisure activity and back symptoms. The relatively weak association between physical activity and MSS in the present study may be caused by a lack of specificity in the questions on this subject.

Methodological considerations
A part of the SNQ was used to record MSS in this study. The test–retest reliability for the SNQ has been found to be satisfactory. The answers from ‘never’ to ‘very often’ have been tested for lower back pain and found to correspond well to answers in the SNQ, categorized into specified numbers of days. Several studies have found the validity of the SNQ acceptable for assessing the prevalence of MSS.

Questionnaires have been proven as the most obvious way to survey MSS in a large number of workers and as an epidemiological instrument. The response rate in this study was very high. This was probably due to the cooperation with the plants and because the questionnaires were distributed and collected at special meetings held with the workers. This high response rate increases the potential to generalize from this study.

Since this study was part of an intervention study to improve musculoskeletal health among employees in the aluminium industry, workers may have over-reported MSS because of their interest in improving their working environment; the results for prevalence must therefore be interpreted with caution. However, Holmstrom and Moritz found that workers tended to under-report lower back symptoms in questionnaire surveys, arguing against major over-reporting in this study. Some of the non-responders in this study were employees who were absent because of sickness when the questionnaires were completed. Some of these were probably absent because of MSS, and this may have contributed to under-reporting MSS.

A cross-sectional design was chosen for the study to provide a baseline for an intervention study. Because of the cross-sectional design and the indirect measure of exposure, it is difficult to interpret the findings in this study as evidence of causal relationships. No causality can be proved, because both the dependent and independent variables are being measured at the same time. Such a cause–effect relationship will be investigated by using a follow-up study in the same population. The effects on health will be measured after an intervention on possible risk factors.

CONCLUSION
This study found that manual operators have more MSS than office workers. Since MSS among operators, which affects most areas of the body, is related to the duration of employment, this suggests that the higher risk of musculoskeletal problems is related to the working environment.

Further epidemiological studies concerning work-related MSS both for male and female operators are needed to find specific risk factors of the working environment in the aluminium industry.

ACKNOWLEDGEMENTS
The project was initiated by the Aluminium Industry in Norway and is a cooperation project between Elkem Aluminium Lista, Elkem Aluminium Mosjøen, Hydro Aluminium Karmøy, Hydro Aluminium Sunddal, Hydro Aluminium Holmestrand, Hydro Aluminium Høyanger, Hydro Aluminium Årdal, Årdal Carbon, Sør-Norge Aluminium Husnes AS, Aluminiumindustriens Miljøsekretariat and the University of Bergen.

REFERENCES


**APPENDIX**

The questionnaire used for musculoskeletal symptoms

<table>
<thead>
<tr>
<th>Musculoskeletal symptoms</th>
<th>Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
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<td>□</td>
<td>□</td>
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<td>□</td>
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<tr>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
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<td>□</td>
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<tr>
<td>Upper back</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Lower back</td>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
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<td>Hip</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
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<td>Ankle/foot</td>
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<td>□</td>
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