Chapter 3

Musculoskeletal complaints in transverse upper limb reduction deficiency and amputation in the Netherlands: prevalence, predictors, and effect on health


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Abstract

Objectives (1) To determine the prevalence of musculoskeletal complaints (MSCs) in individuals with upper limb absence in The Netherlands, (2) to assess the health status of individuals with upper limb absence in general and in relation to the presence of MSCs, and (3) to explore the predictors of development of MSCs and MSC-related disability in this population.

Design Cross-sectional study: national survey.

Setting Twelve rehabilitation centers and orthopedic workshops.

Participants Individuals (n=263; mean age, 50.7±16.7y; 60% men) ≥18 years old, with transverse upper limb reduction deficiency (42%) or amputation (58%) at or proximal to the carpal level (response, 45%) and 108 individuals without upper limb reduction deficiency or amputation (n=108; mean age, 50.6±15.7y; 65% men) (n=371).

Intervention Not applicable.

Main outcome measures Point and year prevalence of MSCs, MSC-related disability (Pain Disability Index), and general health perception and mental health (RAND-36 subscales).

Results Point and year prevalence of MSCs were almost twice as high in individuals with upper limb absence (57% and 65%, respectively) compared with individuals without upper limb absence (27% and 34%, respectively) and were most often located in the nonaffected limb and upper back/neck. MSCs were associated with decreased general health perception and mental health and higher perceived upper extremity work demands. Prosthesis use was not related to presence of MSCs. Clinically relevant predictors of MSCs were middle age, being divorced/widowed, and lower mental health. Individuals with upper limb absence experienced more MSC-related disability than individuals without upper limb absence. Higher age, more pain, lower general and mental health, and not using a prosthesis were related to higher disability.

Conclusions Presence of MSCs is a frequent problem in individuals with upper limb absence and is associated with decreased general and mental health. Mental health and physical work demands should be taken into account when assessing such a patient. Clinicians should note that MSC-related disability increases with age.
Introduction

Musculoskeletal complaints (MSCs) are a common problem in individuals with upper limb absence because of congenital reduction deficiency or acquired amputation.\textsuperscript{4–9} Prevalence of MSCs varies between the affected limb, nonaffected limb, back, or neck and ranges between 23\% (in the nonaffected hand)\textsuperscript{5} and 64\% (in the back).\textsuperscript{6} MSC is an umbrella term for disorders that develop because of repetitive movements, awkward postures, and force.\textsuperscript{32,33} A multidisciplinary consensus defined complaints of the arms, neck, and/or shoulder as MSCs not caused by acute trauma or any systemic disease.\textsuperscript{3} In the general population of The Netherlands, it has a 12-month prevalence of 37\% among individuals \( \geq \) 25 years of age.\textsuperscript{63} Ample evidence exists about the relation between physical demands and MSCs\textsuperscript{32,33,64–67}; additionally, sex, age, marital status, employment status, educational level,\textsuperscript{68} and low (coworker) support\textsuperscript{64,66,69,70} may contribute to the risk of MSCs. Furthermore, poor self-reported physical fitness has also been linked to MSCs.\textsuperscript{71} Presence of MSCs may have far-reaching consequences for work,\textsuperscript{72} health-related quality of life, and use of health care facilities and may cause limitations in daily life.\textsuperscript{68} In individuals with upper limb absence, higher physical demand of the nonaffected arm and hand, and the necessity of compensatory movements, might contribute to high levels of MSCs. Currently, knowledge regarding consequences of MSCs in individuals with upper limb absence is sparse. Relations between MSCs across several anatomic locations and decreased general and mental health have been described in individuals with acquired amputation\textsuperscript{7}; however, it is unknown whether these results can be generalized to individuals with reduction deficiency. Information regarding predictors of MSCs and MSC-related disability in individuals with upper limb absence is lacking; only prosthesis use has been studied repeatedly, but no relation with presence of MSCs was found.\textsuperscript{4,7–9} More insight as to predictors would help to target early prevention of MSCs in individuals with upper limb absence.

We hypothesize that (1) the prevalence of MSCs in individuals with upper limb absence is higher compared with individuals without upper limb absence and (2) presence of MSCs is negatively associated with health. Furthermore, we aim to compare individuals with reduction deficiency and acquired amputation and explore predictors of development of MSCs and MSC-related disability in this population.
Methods

Participants and procedure

Between January and April 2013, 12 Dutch rehabilitation centers and orthopedic workshops sent a postal survey to eligible participants: adults (≥18y) with unilateral upper limb absence (transverse reduction deficiency or acquired amputation) at or proximal to the carpal level. Amputations should have been performed at least 1 year previously (to ensure the patient is stable). Moreover, participants with insufficient understanding of the written Dutch language were excluded. The returned surveys were checked for duplicates.

A sample of individuals without upper limb absence, consisting of acquaintances of the researchers, answered the same survey, minus the upper limb absence-related questions, between June and August 2013. To create a similar age and sex distribution between groups, recruitment was based on these characteristics.

This study was approved by the local medical ethical committee (M12.128984). Participants signed an informed consent form before answering the survey and received an incentive of €10 when returning the survey.

Survey

A survey was compiled by the researchers and assessed and pilot tested by field experts, fellow researchers, and a patient with a longitudinal upper limb reduction deficiency. The survey consisted of 104 questions of which 46 to 88 questions were used for this article, depending on prosthesis use, presence of MSCs, and employment status. The main outcome measures were presence of MSCs and disability. Presence of MSCs was assessed using the question: “Did you have regular complaints of the muscles, tendons, and/or bones during the last 4 weeks, which were not caused by an accident, sports injury, infection, or joint disease?” and a similar question concerning complaints during the last year, lasting for a minimum of 4 consecutive weeks. Location and type of complaint (pain, stiffness, muscle weakness, and tingling) were identified. Phantom and residual limb pain were identified as separate locations of complaints and were therefore not considered to be an MSC. Furthermore, it was asked what they had done themselves to diminish the complaints and if a health care professional was consulted during the last year because of the complaints. If MSCs were present, disability was assessed with the Pain Disability Index, which is a valid and reliable questionnaire to evaluate the influence of complaints on the 7 components of daily life. Scores were summed and range from 0 to 70, with a higher score representing higher disability.

The following variables were assessed for their relation with MSCs and disability: personal characteristics; characteristics of the absent limb; current prosthesis use (yes if a prosthesis was worn, regardless of hours of use), including type of prosthesis used; and employment status, including if the person was employed, work productivity, and perceived physical work demands. The latter was measured with the Upper Extremity Work Demands...
Scale, which consists of 7 questions about object handling and movements of the upper extremity during work. The items were selected from the Dutch Musculoskeletal Questionnaire, which has discriminative power for different worker groups and significant concurrent validity with MSCs of the low back and neck/shoulder. The Upper Extremity Work Demands Scale itself has not yet been validated. Each question has 4 possible answers, ranging from rarely or never to almost always. Answers are summed, giving a score ranging from 7 (lowest work demands) to 28 (highest work demands). Employment details and work productivity are not reported in this article.

The subscales general health perception, mental health (each 5 items), and pain (2 items) from the RAND-36 were included. The pain subscale, which enquires about the average pain and the bothersomeness of the pain during the last 4 weeks, was only answered by participants with MSC-related pain during the last 4 weeks. Individuals with other types of complaints (eg, stiffness) answered the same questions with regard to their complaint (complaint score). Outcomes were converted to a 0 to 100 scale, with a higher score indicating better health/less pain. Furthermore, presence of other health problems (comorbidity) was asked.

Subscales active, avoidance, and support seeking (7, 8, and 6 items, respectively) of the Utrecht Coping List, which has sufficient internal consistency and construct validity and is used in the general population, were administered. Answers were scored on a 4-point Likert scale, with a score of 1 to 4, and summed for each subscale. The score ranges are 7 to 28, 8 to 32, and 6 to 24, respectively. A higher score indicates greater presence of the particular coping style.

Furthermore, if MSCs were present, individuals with upper limb absence answered 2 statements regarding whether it is normative to have MSCs when having upper limb absence and if they supposed that their MSC is related to upper limb absence, on a 5-point Likert scale, ranging from completely agree to completely disagree.

**Statistical analysis**

Point and year prevalence of MSCs were calculated as the number of individuals with MSCs during the last 4 weeks and last year, respectively, as a percentage of all individuals.

Categorical data were analyzed with the chi-square test of independence. Continuous data were analyzed with the independent t test and 1-way analysis of variance (including a Bonferroni correction in the post hoc analyses) or a Kruskal-Wallis test (depending on number of groups and homogeneity of variance checked with the Levene statistic). If a missing variable was detected, the case was omitted from the analysis. Moreover, multivariate regression was used to determine predictors of MSCs and MSC-related disability in individuals with upper limb absence. First, marital status, side of upper limb absence, level of upper limb absence (above or through elbow/below elbow), employment status (yes/no), presence of comorbidity, general health perception, mental health, and coping styles were analyzed univariately. For analysis of MSC-related disability, the pain score (complaint score for participants with other types of complaints) was included.
Second, the following variables were entered as independent variables in multivariate logistic (presence of MSCs) or linear (MSC-related disability) regression analysis in 1 step: sex, age, age squared (because of the expected bell-shaped relation with the presence of MSCs), level of education, cause of upper limb absence, current prosthesis use (yes/no), and all variables from step 1 with a \( P \) value < .100. In linear regression, residuals were checked for a normative distribution. The \( P \) values \( \leq .05 \) were considered to indicate statistically significant differences. Data are presented as mean±SD unless otherwise stated. Independent \( t \) test results are presented as \( P \) value and mean difference with 95% confidence interval (CI) of the difference. Statistical analysis was performed using the SPSS 20.0 software package.

Furthermore, if MSCs were present, individuals with upper limb absence answered 2 statements regarding whether it is normative to have MSCs when having upper limb absence and if they supposed that their MSC is related to upper limb absence, on a 5-point Likert scale, ranging from completely agree to completely disagree.

Results

The response was 45% and calculated as follows: 627 surveys were sent out, of which 6 were returned unanswered. Furthermore, 4 duplicates (1 survey and 3 through personal contact with researchers) and 14 ineligible subjects (11 surveys and 3 through personal contact with researchers) were detected, resulting in 603 eligible surveys. Of the 270 surveys that were returned and eligible for analysis, 263 surveys were actually included; 7 were omitted because of insufficient answers. A total of 111 individuals were asked to complete the questionnaires for the individuals without upper limb absence group; of these, 3 were omitted because the surveys were insufficiently answered. Therefore, 108 surveys were found to be suitable for analysis (97%). The characteristics of the participants (reduction deficiency: \( n=110; 42\% \); acquired amputation: \( n=153; 58\% \)) are presented in table 1.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>RD (n=110)</th>
<th>AA (n=153)</th>
<th>RD and AA compared (p)</th>
<th>ULA (RD and AA combined) (n=263)</th>
<th>Controls (n=108)</th>
<th>ULA and controls compared (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex: male</td>
<td>45 (40.9)</td>
<td>111 (73.2)</td>
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<td>157 (59.7)</td>
<td>70 (64.8)</td>
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<td>Age (y)</td>
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<td>54.6±14.8</td>
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<td>50.7±16.7</td>
<td>50.6±15.7</td>
<td>0.963</td>
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<td>Age categorized</td>
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<td>18-30y</td>
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<td>31-40y</td>
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<td></td>
<td>35 (13.3)</td>
<td>18 (16.7)</td>
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<td>41-50y</td>
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<td>54 (20.5)</td>
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<td>51-60y</td>
<td>23 (20.9)</td>
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<td>56 (21.3)</td>
<td>23 (21.3)</td>
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<td>61-70y</td>
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<td>34 (22.2)</td>
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<td>48 (18.3)</td>
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<td>≥71y</td>
<td>8 (7.3)</td>
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<td>Level of education</td>
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<tr>
<td>None or low</td>
<td>32 (29.1)</td>
<td>73 (48.3)</td>
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<td>105 (40.2)</td>
<td>14 (13.1)</td>
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<td></td>
<td>88 (33.7)</td>
<td>31 (29.0)</td>
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<td>High</td>
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<td>68 (26.1)</td>
<td>62 (57.9)</td>
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<td>.032*</td>
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<td>Single</td>
<td>34 (30.9)</td>
<td>23 (15.0)</td>
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<td>57 (21.7)</td>
<td>11 (10.2)</td>
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<td>Living together or married</td>
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<td>180 (68.4)</td>
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<td>Divorced or widowed</td>
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<td>11 (10.2)</td>
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<td>Employed</td>
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<td>64 (41.8)</td>
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<td>135 (51.3)</td>
<td>74 (68.5)</td>
<td>.003*</td>
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<td>Side of ULA: right</td>
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<td>.005*</td>
<td>110 (41.8)</td>
<td>N/A</td>
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<tr>
<td>Level of ULA</td>
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<td>&lt;.001*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Above elbow†</td>
<td>12 (10.9)</td>
<td>72 (47.1)</td>
<td></td>
<td>84 (31.9)</td>
<td>N/A</td>
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<tr>
<td>Transradial</td>
<td>82 (74.5)</td>
<td>46 (30.1)</td>
<td></td>
<td>128 (48.7)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td>16 (14.5)</td>
<td>35 (22.9)</td>
<td></td>
<td>51 (19.4)</td>
<td>N/A</td>
<td></td>
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<tr>
<td>Age at amputation (y)</td>
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<td></td>
</tr>
<tr>
<td>N/A</td>
<td>29.9±16.4</td>
<td>N/A</td>
<td></td>
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<td>Time since amputation (y)</td>
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<tr>
<td>N/A</td>
<td>25.3±19.2</td>
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<td></td>
<td>N/A</td>
<td>N/A</td>
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<td>Causes of amputation</td>
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<tr>
<td>Trauma</td>
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<td>Cancer</td>
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<td>Vascular disease</td>
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<tr>
<td>Other‡</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Current prosthesis use</td>
<td>92 (83.6)</td>
<td>117 (76.5)</td>
<td>.156</td>
<td>209 (79.5)</td>
<td>N/A</td>
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### Table 1 Continued

<table>
<thead>
<tr>
<th>Type of prosthesis</th>
<th>RD (n=110)</th>
<th>AA (n=153)</th>
<th>RD and AA compared (p)</th>
<th>ULA (RD and AA combined) (n=263)</th>
<th>Controls (n=108)</th>
<th>ULA and controls compared (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmetic</td>
<td>43 (47.3)</td>
<td>46 (39.7)</td>
<td>N/A</td>
<td>89 (43.0)</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Myoelectric</td>
<td>30 (33.0)</td>
<td>45 (38.8)</td>
<td>N/A</td>
<td>75 (36.2)</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Body powered</td>
<td>12 (13.2)</td>
<td>16 (13.8)</td>
<td>N/A</td>
<td>28 (13.5)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Other</td>
<td>6 (6.6)</td>
<td>9 (7.8)</td>
<td>N/A</td>
<td>15 (7.2)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Presence of comorbidity</td>
<td>43 (39.1)</td>
<td>57 (37.3)</td>
<td>.797</td>
<td>100 (38.0)</td>
<td>21 (19.4)</td>
<td>.001*</td>
</tr>
</tbody>
</table>

NOTE. Values are n(%), mean±SD, or as otherwise indicated. Because of missing data, not all values add up to the group totals. Missing values never exceeded the level of 2% for any variable, with exception of the age at amputation (5 missing values). Controls are individuals without upper limb absence.

Abbreviations: AA: acquired amputation; N/A: not applicable; RD: reduction deficiency; ULA: upper limb absence.

*Statistically significant at \( p \leq .05 \); † Amputation at the level of the shoulder, with or without amputation of the scapula and clavicle, transhumeral, or through elbow; ‡ Most common other causes of amputations were amputation after complex regional pain syndrome type 1 (n=4), brachial plexus injury/paralysis (n=3), or infection (n=3).
Prevalence and characteristics of the MSCs

Point and year prevalence of MSCs were both approximately twice as high in individuals with upper limb absence than individuals without upper limb absence (table 2). Furthermore, point prevalence differed significantly between the ages of 31 to 60 years (figure 1) and did not differ between individuals with reduction deficiency (n=59; 54%) and acquired amputation (n=90; 59%; \( \phi = .052; \) chi-square: \( p = .402 \)) and between current prosthesis users (n=113; 54%) and nonusers (n=36; 67%; \( \phi = -.103; \) chi-square: \( p = .096 \)). In individuals with acquired amputation, point prevalence of MSCs did not differ between participants with an amputation of the dominant hand (n=47; 65%) and those with an amputation of the nondominant hand (n=42; 55%; \( \phi = .109; \) chi-square: \( p = .182 \)). Finally, time since amputation was unrelated to presence of MSCs (\( t \) test: \( P = .202 \); mean difference, 4.3; 95% CI, -2.3 to 10.9).

MSCs were most commonly located in the unaffected limb and were often chronic (lasting at least 3mo) (table 2). Many individuals (68% of those with MSCs during the last year) experienced >1 type of complaint. Pain scores did not differ between individuals with reduction deficiency (n=54; mean score, 55.8±17.6) and acquired amputation (n=72; mean score, 51.8±18.9; \( t \) test: \( p = .232 \); mean difference, 4; 95% CI, -2.6 to 10.5) or prosthesis users (n=95; mean score, 55.2±17.3) and nonusers (n=31; mean score, 48.4±20.9; \( t \) test: \( p = .074 \); mean difference, -6.8; 95% CI, -14.3 to 0.7).

MSCs and health status

Many individuals with upper limb absence consulted a health care professional for their MSCs (see table 2). Individuals with reduction deficiency (n=109, 73.3±21.9) and acquired amputation (n=152, 68.0±22.2) did not differ regarding general health perception (\( t \) test: \( p = .057 \); mean difference, 5.3; 95% CI, -0.2 to 10.8) and mental health (n=110, 76.2±15.9 and n=153, 74.0±18.5, respectively; \( t \) test: \( p = .325 \); mean difference, 2.2; 95% CI, -2.1 to 6.5). General health perception and mental health were lower in individuals with upper limb absence who experienced MSCs compared with those without MSCs and individuals without upper limb absence (table 3). When having MSCs, individuals with acquired amputation (n=90, 26.3±16.9) experienced more disability than individuals with reduction deficiency (n=59, 19.8±13.9; \( t \) test: \( p = .016 \); mean difference, -6.5; 95% CI, -11.7 to -1.2). Individuals with upper limb absence experienced the most disability in the domains of family and household, recreation, and work (all median scores of 4; interquartile ranges, 2-7).

Of the individuals with upper limb absence who experienced MSCs during the last 4 weeks, 74 (50%) completely or strongly agreed that having complaints is normative when having upper limb absence (2 missing values). Furthermore, 134 (91%) completely or strongly agreed that their complaints are partly or completely caused by upper limb absence (2 missing values).
Predictors of MSCs and MSC-related disability

Multivariate logistic regression analysis identified the following variables as predictors of MSCs in individuals with upper limb absence: age squared, being divorced/widowed, absence of the right limb, and lower mental health (table 4). Predictors of higher disability in individuals with upper limb absence who experienced MSCs were higher age, low pain score (indicating more pain), lower general and mental health, and no prosthesis use (table 5). The explained variance of the final model was 51%.

Figure 1 Presence of MSCs during the last four weeks in individuals with reduction deficiency (RD), acquired amputation (AA), and individuals without upper limb absence (controls) for different age categories (whiskers represent the standard error of the mean).

Chi-square analyses identified significant differences in point prevalence of MSCs between individuals with upper limb absence and controls for the age categories 31 to 40 years (F=-.305, p=.026), 41 to 50 years (F=-.506, p=.001), and 51 to 60 years (F=-.227, p=.044). No statistical significance was found for the other age categories.
Table 2 Characteristics of MSC in individuals with ULA and controls.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ULA (n=263)</th>
<th>Controls (n=108)</th>
<th>P</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point prevalence MSCs total</td>
<td>149 (56.7)</td>
<td>29 (26.9)</td>
<td>&lt;.001*</td>
<td>-.271</td>
</tr>
<tr>
<td>Year prevalence MSCs total</td>
<td>171 (65.0)</td>
<td>37 (34.3)</td>
<td>&lt;.001*</td>
<td>-.282</td>
</tr>
<tr>
<td>High back and/or neck</td>
<td>112 (42.6)</td>
<td>21 (19.4)</td>
<td>&lt;.001*</td>
<td>-.219</td>
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<tr>
<td>Low back</td>
<td>71 (27.0)</td>
<td>9 (8.3)</td>
<td>&lt;.001*</td>
<td>-.206</td>
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<tr>
<td>Affected limb/nondominant limb†</td>
<td>54 (20.5)</td>
<td>11 (10.2)</td>
<td>.019*</td>
<td>-.122</td>
</tr>
<tr>
<td>Nonaffected limb/dominant limb†</td>
<td>121 (46.0)</td>
<td>18 (16.8)</td>
<td>&lt;.001*</td>
<td>-.273</td>
</tr>
<tr>
<td>Shoulders</td>
<td>87 (33.1)</td>
<td>11 (10.3)</td>
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<tr>
<td>Upper arm</td>
<td>41 (15.6)</td>
<td>1 (0.9)</td>
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<tr>
<td>Elbow</td>
<td>38 (14.4)</td>
<td>6 (5.6)</td>
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<tr>
<td>Forearm</td>
<td>31 (11.8)</td>
<td>2 (1.9)</td>
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<tr>
<td>Wrist</td>
<td>43 (16.3)</td>
<td>2 (1.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand</td>
<td>62 (23.6)</td>
<td>3 (2.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thumb</td>
<td>25 (9.5)</td>
<td>1 (0.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of sites of complaints, mean±SD</td>
<td>3.4±2.1</td>
<td>1.9±1.1</td>
<td>&lt;.001*</td>
<td>1.5 (1.0; 2.0)</td>
</tr>
<tr>
<td></td>
<td>(IQR: 2.0; 4.0)</td>
<td>(IQR: 1.0; 2.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of complaints</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>144 (84.7)</td>
<td>31 (83.8)</td>
<td>.888</td>
<td>-0.10</td>
</tr>
<tr>
<td>Stiffness</td>
<td>73 (42.9)</td>
<td>21 (56.8)</td>
<td>.126</td>
<td>-.106</td>
</tr>
<tr>
<td>Muscle weakness</td>
<td>69 (40.6)</td>
<td>6 (16.2)</td>
<td>.005*</td>
<td>-.194</td>
</tr>
<tr>
<td>Tingling</td>
<td>64 (37.6)</td>
<td>5 (13.5)</td>
<td>.005*</td>
<td>-.196</td>
</tr>
<tr>
<td>Duration of MSCs</td>
<td></td>
<td></td>
<td>&lt;.001*</td>
<td>.282</td>
</tr>
<tr>
<td>≤3mo</td>
<td>25 (14.6)</td>
<td>13 (35.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;3mo but &lt;1y</td>
<td>22 (12.9)</td>
<td>10 (27.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥1y</td>
<td>124 (72.5)</td>
<td>14 (37.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain score (RAND-36), mean±SD</td>
<td>53.5±18.4</td>
<td>68.6±10.6</td>
<td>&lt;.001*</td>
<td>-15.1 (-23.3; -6.9)</td>
</tr>
<tr>
<td>Health care use</td>
<td>107 (62.6)</td>
<td>10 (27.0)</td>
<td>&lt;.001*</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2 Continued

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ULA (n=263)</th>
<th>Controls (n=108)</th>
<th>P</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measures to diminish complaints&lt;sup&gt;II&lt;/sup&gt;</td>
<td>154 (90.1)</td>
<td>90 (52.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pay better attention to physical posture</td>
<td>61 (35.7)</td>
<td>51 (29.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrain from certain movements or actions</td>
<td>25 (14.6)</td>
<td>13 (7.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use pain medication</td>
<td>18 (10.5)</td>
<td>21 (44.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worked less</td>
<td>10 (5.9)</td>
<td>9 (23.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used my prosthesis more</td>
<td>10 (6.6)</td>
<td>7 (14.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used my prosthesis less</td>
<td>18 (10.5)</td>
<td>21 (44.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE. Values are n (%) or as otherwise indicated. Because of missing data, not all values add up to the group totals. Missing values never exceeded the level of 1% for any variable. Effect sizes are presented as F, with the exception of the effect size of Duration of MSCs, which is given as Cramér’s V. For continuous variables, the mean difference and 95% CI of the difference is provided. Controls are individuals without upper limb absence.

Abbreviations: IQR: interquartile range; ULA: upper limb absence.

* Statistically significant at P<.05; † The affected side of the individuals with ULA was compared with the nondominant side of the controls, and the nonaffected side of individual with ULA was compared with the dominant side of the controls; ‡ This score was calculated for individuals with MSCs during the last 4 weeks, with the type of complaint being pain (ULA: n=126, controls: n=21); § Number and percentage of individuals with ULA and controls that had consulted a health care professional in the last year because of their MSCs; || Number and percentage of individuals with MSCs that had taken measures during the last year to diminish the complaints.
### Table 3 Health, physical work demands, and coping styles in individuals with ULA with and without MSCs during the last 4 weeks and controls.

<table>
<thead>
<tr>
<th>Variable</th>
<th>ULA without MSC (n=114)</th>
<th>ULA with MSC (n=149)</th>
<th>Controls (n=108)</th>
<th>$F_{df_m,df_r}$</th>
<th>$p$</th>
<th>Effect size†</th>
<th>Post hoc comparison between ULA without and with MSC</th>
<th>Post hoc comparison between ULA without MSC and controls</th>
<th>Post hoc comparison between ULA with MSC and controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>General health perception (RAND-36)</td>
<td>74.9±20.9</td>
<td>66.5±22.5</td>
<td>74.7±18.4</td>
<td>.001*</td>
<td></td>
<td></td>
<td>.003*</td>
<td>1.00</td>
<td>.011*</td>
</tr>
<tr>
<td>Mental health (RAND-36)</td>
<td>79.4±14.8</td>
<td>71.5±18.6</td>
<td>80.6±12.4</td>
<td>&lt;.001*</td>
<td></td>
<td></td>
<td>.001*</td>
<td>1.00</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Disability (PDI)</td>
<td>N/A</td>
<td>23.7±16.1</td>
<td>11.4±9.0</td>
<td>12.2 (8.0; 16.5)</td>
<td>.221</td>
<td></td>
<td>.013*</td>
<td>.287</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Physical work demands (UEWD)‡</td>
<td>15.9±4.8</td>
<td>13.7±4.8</td>
<td>12.4±4.3</td>
<td>&lt;.001*</td>
<td></td>
<td></td>
<td>.013*</td>
<td>.287</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Coping styles (UCL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>20.3±4.3</td>
<td>19.7±3.9</td>
<td>20.5±3.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoidance</td>
<td>15.6±3.2</td>
<td>15.7±3.7</td>
<td>15.7±3.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support seeking</td>
<td>12.1±3.4</td>
<td>12.1±3.4</td>
<td>13.5±3.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE. Missing values never exceeded the level of 1% for any variable. General health perception and mental health had a significant Levene’s statistic; therefore, a Kruskal-Wallis test with pairwise comparison was performed and the effect size was not calculated. Disability was assessed for individuals with MSCs during the last 4 weeks with a t test. For the variables assessed with 1-way analysis of variance, the $F$ values are given, including the $df_m$ and the $df_r$. Because sample sizes were slightly different, Gabriel procedure was performed for post hoc analyses. Controls are individuals without upper limb absence.

Abbreviations: $df_m$: degrees of freedom for the effect of the model; $df_r$: degrees of freedom for the residuals of the model; N/A: not applicable; PDI: Pain Disability Index; UCL: Utrecht Coping List; UEWD: Upper Extremity Work Demands Scale; ULA: upper limb absence.

* Statistically significant at $P \leq .05$; † The mean difference (95% CI of the mean difference) is listed or provided as $\eta^2$; ‡ This is only calculated for employed individuals between the age of 18 and 65 (official retirement age in The Netherlands) (ULA without MSCs: n=58, ULA with MSCs: n=84, controls: n=67).
### Table 4 Logistic regression of current presence of MSCs in individuals with ULA (n=259).

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SE</th>
<th>p</th>
<th>OR[Exp(B)]</th>
<th>95% CI for OR[Exp(B)]</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.108</td>
</tr>
<tr>
<td>Sex</td>
<td>-.042</td>
<td>.300</td>
<td>.888</td>
<td>.959</td>
<td>.532; 1.728</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>.086</td>
<td>.051</td>
<td>.092</td>
<td>1.090</td>
<td>.986; 1.205</td>
<td></td>
</tr>
<tr>
<td>Age squared</td>
<td>-.001</td>
<td>.000</td>
<td>.041*</td>
<td>.999</td>
<td>.998; 1.000</td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living together or married</td>
<td>.714</td>
<td>.386</td>
<td>.064</td>
<td>2.043</td>
<td>.959; 4.352</td>
<td></td>
</tr>
<tr>
<td>Divorced or widowed</td>
<td>1.505</td>
<td>.616</td>
<td>.015*</td>
<td>4.505</td>
<td>1.347; 15.075</td>
<td></td>
</tr>
<tr>
<td>Level of education</td>
<td></td>
<td></td>
<td>.108</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>-.663</td>
<td>.343</td>
<td>.054</td>
<td>.516</td>
<td>.263; 1.010</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>-.606</td>
<td>.363</td>
<td>.095</td>
<td>.546</td>
<td>.268; 1.111</td>
<td></td>
</tr>
<tr>
<td><strong>ULA-related predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.160</td>
</tr>
<tr>
<td>Cause of ULA</td>
<td>-.243</td>
<td>.330</td>
<td>.461</td>
<td>.784</td>
<td>.410; 1.498</td>
<td></td>
</tr>
<tr>
<td>Current prosthesis use</td>
<td>-.666</td>
<td>.373</td>
<td>.074</td>
<td>.514</td>
<td>.247; 1.067</td>
<td></td>
</tr>
<tr>
<td>Side of ULA</td>
<td>-.729</td>
<td>.288</td>
<td>.011*</td>
<td>.482</td>
<td>.275; .848</td>
<td></td>
</tr>
<tr>
<td><strong>Remaining predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.205</td>
</tr>
<tr>
<td>Presence of comorbidity</td>
<td>.130</td>
<td>.350</td>
<td>.710</td>
<td>1.139</td>
<td>.573; 2.265</td>
<td></td>
</tr>
<tr>
<td>General health perception (RAND-36)</td>
<td>-.008</td>
<td>.008</td>
<td>.302</td>
<td>.992</td>
<td>.976; 1.007</td>
<td></td>
</tr>
<tr>
<td>Mental health (RAND-36)</td>
<td>-.020</td>
<td>.010</td>
<td>.042*</td>
<td>.981</td>
<td>.962; .999</td>
<td></td>
</tr>
<tr>
<td><strong>Constant†</strong></td>
<td>1.656</td>
<td>1.441</td>
<td>.250</td>
<td>5.240</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: B: regression coefficient; OR: odds ratio; $R^2$: Nagelkerke $R^2$; ULA: upper limb absence.

* Statistically significant at $P<.05$; † Constant for MSCs during the last 4 weeks is an individual with the following features: female sex, marital status single, educational level none or low, the cause of ULA is reduction deficiency, not using a prosthesis, a ULA on the right side, no comorbidity (all coded as 0), a hypothetical age of 0, and a general health perception and mental health score of 0.
Table 5 Linear regression of MSC-related disability in individuals with ULA (n=145).

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SE</th>
<th>p</th>
<th>95% CI for OR[Exp(B)]</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>-.988</td>
<td>2.232</td>
<td>.659</td>
<td>-5.405; 3.430</td>
<td>.078</td>
</tr>
<tr>
<td>Age</td>
<td>.962</td>
<td>.398</td>
<td>.017*</td>
<td>.175; 1.748</td>
<td></td>
</tr>
<tr>
<td>Age squared</td>
<td>-.009</td>
<td>.004</td>
<td>.021*</td>
<td>-5.017; -.001</td>
<td></td>
</tr>
<tr>
<td>Level of education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>-.098</td>
<td>2.588</td>
<td>.970</td>
<td>-5.218; 5.023</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>-1.881</td>
<td>2.638</td>
<td>.477</td>
<td>-7.100; 3.339</td>
<td></td>
</tr>
<tr>
<td><strong>ULA-related predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.105</td>
</tr>
<tr>
<td>Cause of ULA</td>
<td>2.879</td>
<td>2.493</td>
<td>.250</td>
<td>-2.053; 7.811</td>
<td></td>
</tr>
<tr>
<td>Current prosthesis use</td>
<td>-5.395</td>
<td>2.613</td>
<td>.041*</td>
<td>-10.566; -.224</td>
<td></td>
</tr>
<tr>
<td>Level of ULA</td>
<td>1.877</td>
<td>2.377</td>
<td>.431</td>
<td>-2.826; 6.580</td>
<td></td>
</tr>
<tr>
<td><strong>Remaining predictors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.330</td>
</tr>
<tr>
<td>Coping strategy avoidance (UCL)</td>
<td>.467</td>
<td>.300</td>
<td>.122</td>
<td>-1.27; 1.060</td>
<td></td>
</tr>
<tr>
<td>Presence of comorbidity</td>
<td>1.859</td>
<td>2.613</td>
<td>.478</td>
<td>-3.311; 7.030</td>
<td></td>
</tr>
<tr>
<td>General health perception (RAND-36)</td>
<td>-.124</td>
<td>.062</td>
<td>.048*</td>
<td>-.246; -.001</td>
<td></td>
</tr>
<tr>
<td>Mental health (RAND-36)</td>
<td>-.160</td>
<td>.069</td>
<td>.022*</td>
<td>-.295; -.024</td>
<td></td>
</tr>
<tr>
<td>Pain score (complaint score) (RAND-36)</td>
<td>-.285</td>
<td>.064</td>
<td>&lt;.001*</td>
<td>-.411; -1.159</td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>-2.445</td>
<td>2.840</td>
<td>.391</td>
<td>-8.065; 3.175</td>
<td></td>
</tr>
<tr>
<td><strong>Constant†</strong></td>
<td>32.056</td>
<td>13.078</td>
<td>.016*</td>
<td>6.179; 57.934</td>
<td></td>
</tr>
</tbody>
</table>

NOTE. $R^2$ of the total model was .513. MSC-related disability was analyzed for individuals with MSCs during the last 4 weeks only. Outcome variable Pain Disability Index showed good fit of residuals.

Abbreviations: B: regression coefficient; $R^2$: Nagelkerke $R^2$; UCL: Utrecht Coping List; ULA: upper limb absence.

* Statistically significant at $P≤.05$. † Constant for MSC-related disability is the mean value of an individual with MSCs with female sex, none or low level of education, a ULA caused by reduction deficiency, not using a prosthesis, a deficiency at or above the level of the elbow, no comorbidity, no employment (all coded as 0), a hypothetical age of 0, and an avoidance coping strategy, general health perception, mental health, and pain score of 0.
Discussion

The point and year prevalence of MSCs in individuals with upper limb absence were twice as high compared with the individuals without upper limb absence and the general Dutch population. A similar prevalence of MSC in individuals with upper limb absence has been described previously, but mostly in smaller study populations or only in individuals with acquired amputation. One study found a similar rate of chronic pain in individuals with reduction deficiency, whereas another smaller study found a lower prevalence of physical complaints. Our prevalence of MSCs in the nonaffected arm fits well within the range of prevalence found in earlier studies. Because of uncertainty regarding inclusion of residual limb and phantom limb pain, MSCs in the affected limb are difficult to compare between studies. The prevalence of neck (and/or high back) and low back pain in individuals with upper limb absence is high compared with our individuals without upper limb absence group, but relatively low in comparison with earlier studies (40%-62%, depending on anatomic location). Only one study reported a lower prevalence for neck pain (29%).

Our study, which is the first, to our knowledge, to reveal MSC findings in individuals with reduction deficiency and acquired amputation, did not discover a difference in point prevalence of MSCs, despite differences in several personal and upper limb absence-related variables (eg, age, sex, level of education, employment status, deficiency level). However, not all of these variables were significant predictors for MSCs in the statistical model. Evidently, both groups are prone to MSCs. Likely, the explanation of MSCs is multifactorial and includes factors not investigated in the current study (eg, compensatory movements caused by 1-handedness). Although compensatory movements are often mentioned as a risk factor for MSCs, scientific evidence is lacking.

Relation with health

Increased pain intensity and disability compared with individuals without upper limb absence, the often chronic character of the complaints, and a high number of individuals who consulted a health care professional suggest that MSCs are a significant problem in this population. In addition, underestimation of the real clinical problem seems likely because half of the individuals stated that they regarded their MSCs to be a normative feature of upper limb absence. Clinicians and future research should focus on prevention of MSCs. If MSCs are present, general and mental health are perceived to be lower, which is in line with previous research among individuals with acquired amputation. Because of the study design, it is uncertain whether poor mental health is a cause or a result of MSCs and increased disability. Furthermore, the clinical relevance of decreased health cannot be ascertained. Nevertheless, we recommend clinicians focus on mental health as part of prevention and treatment of MSCs and MSC-related disability.
Predictors of MSCs and MSC-related disability

Regression analyses identified several factors, other than health, that should be considered when assessing an individual with upper limb absence. Older individuals should be monitored closely because middle-aged individuals have the highest risk for MSCs, and older age is related to increased disability. The latter relation has also been described in the general population with MSCs. The relation between being divorced/widowed and presence of MSCs has also been described in the general population. This connection may be age-related or caused by increased physical demands (e.g., performance of household tasks without the partner’s help). Interestingly, this relation was not significant in a previous study among individuals with acquired amputation. Although low (coworker) support is related to MSCs, we found no relation between MSCs and coping styles. However, (not) receiving support and possessing a support-seeking coping style are possibly not interchangeable.

The items of the Upper Extremity Work Demands Scale include twisting and bending of the wrist, arm elevations, and repetitive or forceful exertions; these are known predictors of MSCs. Presence of MSCs was related to higher Upper Extremity Work Demands Scale scores, supporting the hypothesis that individuals with upper limb absence are at increased risk for MSCs because of the increased physical demands. However, pain might cause awareness of certain movements, therefore increasing Upper Extremity Work Demands Scale scores. Future research should clarify the relation between pain, perceived physical demands, including compensatory movements, and MSCs.

With a stiff wrist, which most prostheses have, compensatory movements are predominantly made with the trunk and shoulder, which are the locations with many complaints. Currently, prosthesis use does not seem to prevent MSCs, probably because of limited function and degrees of freedom. However, logistic regression revealed prosthesis use as a predictor of less disability. It could be that prosthesis use limits feelings of disablement or that increased disability does not allow prosthesis use; however, true reasons cannot be ascertained. More research about detailed features of prosthesis use and MSCs could help to explain how disability relates to prosthesis use and indicate which developments in prosthetic components might be beneficial.

Study limitations

The response to our survey is comparable with other studies. As a result of privacy regulations, it was not possible to examine details of nonresponders. Therefore, nonresponse bias cannot be ruled out, and characteristics of the study population might not reflect the true population. However, although differences in personal characteristics between individuals with upper limb absence and individuals without upper limb absence were found, the year prevalence of MSCs in the individuals without upper limb absence group was similar to the year prevalence of MSCs in the general population of The Netherlands.
Furthermore, because of the same privacy regulations, some individuals might have received the survey twice, which may have influenced the response. However, the rehabilitation centers and orthopedic workshops covered different parts of The Netherlands; therefore, we do not expect that this occurred often. Because several orthopedic workshops disseminated the survey, the rate of prosthesis use might not reflect the true rate of prosthesis used in The Netherlands. Because of the relatively large number of statistical analyses, a type I error might have occurred; therefore, careful interpretation of the results is necessary.

Conclusions

Almost two-thirds of all individuals with upper limb absence who responded to the survey had MSCs, lasting for a minimum of 4 consecutive weeks in the last year, which was twice as much compared with individuals without upper limb absence. This supports our hypothesis that the point and year prevalence of MSCs are higher in individuals with upper limb absence than in individuals without upper limb absence. MSCs were most often located in the nonaffected limb and upper back/neck. Presence of MSCs was associated with higher perceived physical work demands and lower general and mental health. Clinically relevant predictors of presence of MSCs were middle age, being divorced/widowed, and lower mental health. Prosthesis use was not associated with presence of MSCs. Finally, older age, lower general and mental health, and more pain were related to higher disability.