Does muscle strength predict future musculoskeletal disorders and sickness absence?

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Abstract

Introduction

Reducing long-term sickness absence (LTSA) has for several years been a prioritized issue for governments within the European Union [1,2]. The resulting intensive research of predictors for LTSA has not only revealed the large complexity of the phenomenon [3] but also identified musculoskeletal disorders (MSD) as one of the major risk factors for LTSA [4,5]. In particular, symptoms of the low back and the neck/shoulder region are shown to be associated with LTSA [6,7].

The association between physical work exposures and muscle strength has been proven in previous research [8–12]. Furthermore, muscle strength is independently associated with chronic diseases [13], mortality and cancer [14] and is therefore becoming a recognized factor for preserving public health [15].

With regard to the association between muscle strength and MSD, several studies have pointed towards an association between strength of back muscles and a lowered risk for low back symptoms [16–18]. Contrary, other studies have not found a protective effect of high muscle strength on MSD [19]. Furthermore, a systematic review of 26 prospective cohort studies on physical capacity and musculoskeletal pain found inconclusive evidence for a relation between trunk muscle strength and future low back pain [20].

The association between muscle strength and sickness absence is only scarcely examined in the general working population. In a cross-sectional study of 7179 male employees of the Finnish military, Kyrolainen and co-workers found that poor muscle capacity and high body mass index (BMI) increased the risk of sickness absence [21]. However, no longitudinal studies on the relation between muscle strength and sickness absence have previously been performed on a general working population.

The aim of this study was to investigate if workers with low muscle strength have an excess risk for future MSD and LTSA compared with stronger workers. For this purpose, muscle strength of the trunk, neck, shoulder and hand from a representative sample of Danish workers

Background

High muscle strength is considered relevant for preventing musculoskeletal disorders and long-term sickness absence. However, prospective studies on the association between muscle strength and future musculoskeletal disorders and long-term sickness absence are few and show contrasting results.

Aims

To investigate the association between low muscle strength and future musculoskeletal disorders and long-term sickness absence.

Methods

Muscle strength in trunk flexion and extension, shoulder elevation and abduction as well as handgrip was recorded from a representative sample of Danish workers (n = 421) in 1995. Musculoskeletal disorders were recorded 5 years later (in 2000). Information on long-term sickness absence was retrieved from a register of social transfer payments in the period 1996–2007.

Results

Regression analyses adjusted for age, gender, smoking, body mass index and physical work demands showed that workers with low muscle strength (the lowest quartile) of trunk extension and flexion, shoulder elevation and abduction and handgrip did not have a significantly increased risk for future musculoskeletal disorders or long term sickness absence compared with stronger workers.

Conclusions

Low muscle strength does not seem to be a good predictor for musculoskeletal disorders and long-term sickness absence in the general working population.

Key words

Musculoskeletal symptoms; pain; physical capacity; prospective; sick leave; sickness absenteeism.
in 1995 was linked to National registers with data on MSD in 2000 and sickness absence in the period from 1996 to 2007.

Methods

Measurements of muscle strength were taken from a subsample of the Danish National Working Environment Cohort Study (DWECS) in 1995 [22]. The data collection took place in nine counties in Denmark, using a mobile measurement station. The study population is described in detail elsewhere [10]. The study was approved by the Danish Data Protection Agency. According to Danish law, questionnaire and register-based studies do not need approval by ethical and scientific committees nor informed content.

Sociodemographic information, data on work-related factors and health behaviour were retrieved from the DWECS questionnaire in 1995 and 2000.

Muscle strength was measured by strain gauge dynamometers during isometric maximal voluntary contractions of backward extension and forward flexion of the trunk, shoulder elevation, shoulder abduction and hand-grip according to standard and validated procedures [23]. Backward extension and forward flexion of the trunk were performed in standing position with a strap around the shoulders at the level of insertion of the deltoid muscle. Shoulder elevation and shoulder abduction were performed on two Bofors dynamometers in sitting position, with no floor contact. Handgrip strength of the dominant hand was performed on a Jamar dynamometer in sitting position with the elbow flexed 90°. For descriptions in more detail, see Faber et al. [10]. For each respective task, maximal contractions were performed at least three times with at least 30-s rest between the contractions. If the last attempt was more than 5% larger than the previous, the test was repeated up to a maximum of five times. The subject was verbally instructed to slowly increase force, maintain a maximal force for about 2 s and then slowly reduce the force. The highest value obtained during a 1-s period of any attempt was used as maximal strength.

The sample was divided into groups according to gender, and the respective 25th percentiles of muscle strength were calculated. Workers with less strength than the 25th percentile (the lowest quartile) were defined as having low muscle strength.

Symptoms in the low back, neck/shoulder and hand/wrist in 1995 was self-rated by the question: ‘Have you had symptoms (pain or discomfort) in your low back/neck/shoulder/wrist/hand within the last 12 months?’ (yes/no). This item was chosen to provide a general picture of pain during the last year, and the question has shown to strongly predict LTSA and early retirement pensions in other studies [26].

Data on MSD in 1995 were followed up in 2000 by the question: ‘Please indicate the average degree of symptoms (pain or discomfort) in your low back, neck/shoulder and wrist/hand symptoms within the last three months on a scale from 0 to 9. Zero indicates no symptoms at all and 9 indicates the worst possible pain.’ This scale was earlier proven valid and reliable [24,25]. Pain on level 3 or more was defined as musculoskeletal symptoms [26].

Data on LTSA was obtained from a register of social transfer payments (DREAM) that was merged with DWECS. DREAM contains weekly information on granted sickness absence compensation for all citizens in Denmark [27]. LTSA was defined as having sickness absence spells for all causes for a period of more than two consecutive weeks in the follow-up period from time of muscle strength measurement (9 September 1996 to 29 August 1997) to the end of 2007.

Information on physical job demands was obtained from the DWECS questionnaire in 1995 and was measured by the sum of odd working positions for some duration. Physical job demands included working standing, with the back heavily bent forward with no support for hands or arms, or working with twisted or bent body, at least three-quarters of the working hours, working with the hands lifted to shoulder height or higher or the neck heavily bent forward or squatting or kneeling at least half of the working hours. Also included were lifting objects 1–7 kg more than 10 times an hour, 8–30 kg at least once per hour or lifting objects above 30 kg. There was no control for employees changing work tasks during the follow-up.

The questions are described in detail elsewhere [28].

Initially, correlation analyses were performed on all explanatory variables. The correlation coefficient was below 0.25 for all pairs of covariates except between the five measures of muscle strength for which the coefficients varied between 0.74 and 0.84. Therefore, the effect of muscle strength of each measured body region was calculated with separate models. The cut-off points of low muscle strength in the model were set to the lowest quartile and were calculated separately for males and females.

Separate analyses were performed on muscle strength in 1995 and the two outcomes: MSD in 2000 and LTSA in a 10-year follow-up period. The Cox proportional hazard model [29] was used for modelling the probability of LTSA in the period 1996–2007, and logistic regression was used to model MSD in 2000.

In the Cox analyses, persons who retire are granted early retirement pension, emigrate or die during the period are censored at the time of the event. If a person experiences LTSA in the period 1996–2007, the survival time is non-censored and referred to as event time. The association between muscle strength in each respective body region on LTSA was modelled separately. The analyses were performed with control for age, BMI, physical work demands and smoking habits.

In the logistic regressions estimating the effects of muscle strength in 1995 on MSD in the corresponding region in 2000, control was done for age, BMI, physical
work demands, smoking habits and MSD in the respective body region in 1995.

The applied estimation method was maximum likelihood, and the statistical computer programs SAS (version 9.2), with the PHREG and LOGISTIC procedures were used. Results of the Cox analyses are presented in hazard ratios, expressing the estimated increased risk of LTSA for a person with low muscle strength. Similarly, results of the logistic regression analyses are presented in odds ratios expressing the estimated increased risk for MSD for a person with low muscle strength.

Muscle strength was measured on roughly 360 employees in a particular body region, and approximately 38% of these experienced at least one spell of LTSA in the 10-year follow-up period.

Assuming an $R^2$ of 0.1 when regressing a muscle strength measurement on the other independent variables (result of crude analyses of the data), power calculations show that in the Cox analyses there was 87% chance of detecting a true hazard ratio of 2.0 at a significance level of 5%. Similarly, in the logistic regressions, there was a 99% chance of detecting a true odds ratio of 2.0 with an event rate of MSD in 2000 of 15%. Likewise, the chances of detecting a true hazard ratio of 1.4 and a true odds ratio of 1.4 were 38 and 58%, respectively.

### Results

From 5575 employees, 4194 (75%) agreed to participate in a physical examination. Among those, a random sample of 839 was drawn for the physical measurements. Due to missing address or inability to make contact ($n = 98$), refused participation ($n = 169$), not showing up, cancelling appointment ($n = 105$) or exclusion in case of self-reported or measured elevated resting blood pressure, angina pectoris, previous disc prolapse, use of heart or lung medicine or musculoskeletal pain in the specific body region on the test day ($n = 46$), 421 subjects (213 men and 208 women) participated in the study. Demographic data, LTSA and self-rated musculoskeletal disorders of low back, neck/shoulders and wrist/hand are presented in Table 1. Male and female workers were as a mean 39 years old and had a BMI of 25.

Forty-six percent of all participants had experienced pain in the low back or the neck/shoulders within the last year, while only 18% experienced hand or wrist pain. Sixty-one percent of the women and 44% of the men experienced neck/shoulder pain.

The proportion of women having an episode of LTSA in the period 1996–2007 was 42%, and for men, the proportion was 32%.

Table 2 shows the mean values and the 25% cut points for the muscle strength. The muscle strength of men is approximately twice the muscle strength of women in all tasks except for handgrip.

Tables 3 and 4 present the increased risk of MSD in 2000 (Table 3) and LTSA in the period from 1996 to 2007 (Table 4) from having low muscle strength (lowest quartile) in different body regions in 1995. The estimated odds ratio for MSD in the neck/shoulder region for those having low muscle strength in shoulder abduction was 1.39. However, neither this nor the effect on MSD of low muscle strength in any of the other muscle regions was statistically significant.

The estimated hazard ratio for LTSA for those having low muscle strength in shoulder elevation was 1.38. Neither this nor the effect of LTSA of low muscle strength of any of the other muscle regions was statistically significant.

In addition to the model including the sum of physical demands at work (as shown in Tables 3 and 4), the analyses were repeated leaving out the physical demands at work in the model. This did not change the results for any body region.

### Discussion

The present study of a representative sample of Danish workers showed that workers with low muscle strength in different body regions did not have significantly increased risk for future LTSA or for future MSD in the same body region. However, there may be several reasons for this finding.

First, as the risk for MSD in the neck/shoulder region from having low muscle strength in shoulder abduction and the risk for LTSA from having low muscle strength in shoulder elevation was nearly 40%, it cannot be excluded that muscle strength in these body regions has some effects on MSD and LTSA. An explanation for the inability to find significant results in this study may be lack of statistical power. The statistical power analysis showed a 38–58% chance of detecting a true odds ratio of 1.4 at a significance level of 5%, which is not a very high power. However, the results showed no consistency, as many of the risk estimates were in the opposite direction. Therefore, the results indicate that muscle strength does not play any consistent or major role for the future risk of developing MSD or having an episode of LTSA.

Second, in this study, results from a representative sample of workers, and not only those with high physical work demands that may be in greatest need for high muscle strength, were presented. Whether an alternative sample of workers with physically heavy work may reveal a protective effect of high muscle strength in job-specific muscle groups still remains to be shown.

Third, methodological aspects may play a role. Inclusion and exclusion criteria are a general challenge in testing of physical capacity. On one hand, they ensure that only healthy persons are tested. On the other hand, it makes the study group of 421 persons rather small and possibly a selected group. However, it cannot be ruled
Table 1. Demographic variables in 1995, prevalence of MSD in 2000 and LTSA in the period 1996–2007 of male and female workers; mean (±SD)

<table>
<thead>
<tr>
<th></th>
<th>All participants (N = 421)</th>
<th>Male workers (N = 213)</th>
<th>Female workers (N = 208)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>39.0 (11.0)</td>
<td>39.4 (11.4)</td>
<td>38.6 (10.7)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171.6 (8.6)</td>
<td>177.3 (7.0)</td>
<td>165.7 (5.7)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73.4 (13.3)</td>
<td>80.5 (11.6)</td>
<td>66.1 (10.6)</td>
</tr>
<tr>
<td>BMI</td>
<td>24.8 (3.5)</td>
<td>25.6 (3.2)</td>
<td>24.1 (3.7)</td>
</tr>
<tr>
<td>Pain last year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low back (%)</td>
<td>46</td>
<td>50</td>
<td>42</td>
</tr>
<tr>
<td>Neck/shoulders (%)</td>
<td>52</td>
<td>44</td>
<td>61</td>
</tr>
<tr>
<td>Wrist/hand (%)</td>
<td>18</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>LTSA (% cases)</td>
<td>37</td>
<td>32</td>
<td>42</td>
</tr>
</tbody>
</table>

Table 2. Muscle strength of different body regions of male and female workers; mean (±SD) and lowest quartile

<table>
<thead>
<tr>
<th>Maximal strength 1995</th>
<th>All participants (N = 421)</th>
<th>Males, mean (±SD)</th>
<th>Females, mean (±SD)</th>
<th>Males, lowest Quartile</th>
<th>Females, lowest quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk extension (nm)</td>
<td>157.5 (64.7)</td>
<td>203.9 (55.3)</td>
<td>110.5 (30.5)</td>
<td>88.5</td>
<td>176</td>
</tr>
<tr>
<td>Trunk flexion (nm)</td>
<td>142.2 (58.3)</td>
<td>186.9 (45.5)</td>
<td>97.2 (26.4)</td>
<td>82.0</td>
<td>179</td>
</tr>
<tr>
<td>Shoulder elevation (nm)</td>
<td>86.9 (42.5)</td>
<td>119.6 (35.3)</td>
<td>55.9 (19.0)</td>
<td>44.0</td>
<td>176</td>
</tr>
<tr>
<td>Shoulder abduction (nm)</td>
<td>50.7 (26.8)</td>
<td>70.5 (24.2)</td>
<td>31.1 (9.0)</td>
<td>24.5</td>
<td>179</td>
</tr>
<tr>
<td>Handgrip (N)</td>
<td>448.4 (118.5)</td>
<td>543.5 (79.6)</td>
<td>347.6 (49.2)</td>
<td>314.0</td>
<td>201</td>
</tr>
</tbody>
</table>

*a’ n vary due to task-specific exclusion criteria.

Table 3. Frequencies of MSD among workers with low and high muscle strength and odds ratios and confidence intervals of MSD in 2000 from having low muscle strength in 1995

<table>
<thead>
<tr>
<th>Frequency of MSD</th>
<th>n*</th>
<th>Risk for MSD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low strength</td>
<td>High strength</td>
</tr>
<tr>
<td>Trunk extension</td>
<td>9.1</td>
<td>12.6</td>
</tr>
<tr>
<td>Trunk flexion</td>
<td>11.3</td>
<td>12.1</td>
</tr>
<tr>
<td>Shoulder elevation</td>
<td>14.1</td>
<td>18.4</td>
</tr>
<tr>
<td>Shoulder abduction</td>
<td>21.7</td>
<td>16.4</td>
</tr>
<tr>
<td>Handgrip</td>
<td>6.7</td>
<td>7.5</td>
</tr>
</tbody>
</table>

*a’ n vary due to task-specific exclusion criteria.

Table 4. Frequencies of long-term sickness absence among workers with low and high muscle strength and hazard ratios and confidence intervals of LTSA in the period 1996–2007 from having low muscle strength in 1995

<table>
<thead>
<tr>
<th>Frequency of LTSA</th>
<th>n*</th>
<th>Risk for LTSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low strength</td>
<td>High strength</td>
</tr>
<tr>
<td>Trunk extension</td>
<td>32.6</td>
<td>36.6</td>
</tr>
<tr>
<td>Trunk flexion</td>
<td>34.4</td>
<td>36.1</td>
</tr>
<tr>
<td>Shoulder elevation</td>
<td>39.1</td>
<td>34.4</td>
</tr>
<tr>
<td>Shoulder abduction</td>
<td>26.7</td>
<td>39.3</td>
</tr>
<tr>
<td>Handgrip</td>
<td>29.1</td>
<td>39.4</td>
</tr>
</tbody>
</table>

*a’ n vary due to task-specific exclusion criteria.
out that a relatively large proportion of the excluded participants had low muscle strength, which could have weakened a possible association between muscle strength and future risk of MSD and LTSA.

The main strength of this study is the prospective design, combining questionnaire and physical examination at baseline, with a register-based follow-up. This eliminates the risk of common method variance and related bias [30]. However, this study also has limitations. In the applied register for sickness absence (DREAM), the cause of the sickness absence is unknown. Moreover, we have no knowledge about changes in muscular strength or health behavior that could affect risk for LTSA during the long (10 years) follow-up period. Hence, as LTSA is caused by many factors, muscle strength may not be expected to be a significant predictor. Another limitation may be our definition of low and high strength. The cut-off of low muscle strength was fixed to the lowest quartile and calculated separately for males and females in the statistical model, without control for age and anthropometry. As muscle strength normally decreases with increasing age [18], and increases with increasing body height, the low-strength group may have a higher proportion of elderly and small persons than the rest. However, as age and BMI is controlled for in the analyses, this is not likely to affect the study results. A third limitation is the relatively small sample size, not permitting stratified analyses on gender and physical work demands.

With regard to further research, future studies should be performed in larger cohorts enabling specific analyses on workers with high physical work demands among both genders. They should also investigate whether high muscle strength prevents MSD and LTSA among workers with high physical work demands.

Overall, the study suggests that workers with low muscle strength do not have an increased risk of developing MSD or a future episode of LTSA compared with stronger workers. Thus, low muscle strength does not seem to be a decisive factor for future musculoskeletal disorders and long-term sickness absence in the general working population.

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### Conflicts of interest

None declared.

### References


