Chapter 2

Does physical workload moderate the influence of obesity on work ability among construction workers? – A longitudinal study

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Under review
Abstract

**Background:** Obesity and high physical workload are both associated with poor work ability, but the interaction between obesity and high physical workload on work ability is not yet fully understood.

**Methods:** A longitudinal study was conducted among 36,435 Dutch construction workers who participated in at least two periodic medical examinations during the years 2008-2015. Logistic regression analyses were used to investigate the effect of manual material handling and strenuous work postures on the association between obesity and work ability. Confounding effects were tested for age, educational level, smoking, vigorous physical activity, psychosocial work demands, and working hours. Additive interaction between obesity and physical workload on work ability was tested using the relative excess risk due to interaction (RERI).

**Results:** Construction workers with overweight (OR=1.09; 95% CI: 1.02-1.16) or obesity (OR=1.27; 95% CI: 1.17-1.38) had an increased risk of poor/moderate work ability. Exposure to manual material handling (OR=1.58; 95% CI: 1.49-1.68) or strenuous work postures (OR=1.80; 95% CI: 1.70-1.90) also increased the risk of poor/moderate work ability. The effect of the combination of obesity with high physical workload was greater than the sum of the individual effects (strenuous work postures: RERI=0.39; 95% CI: 0.10-0.67; manual material handling: RERI=0.26; 95% CI: 0.02-0.51).

**Conclusions:** Obesity and high physical workload were associated with poor work ability and had a synergistic, negative effect on work ability. Interventions that prevent obesity and high physical workload might have a beneficial effect on work ability.
Background

The growing life expectancy in Western countries and low birth rates have led to an aging working population. Since health declines with age, it has become increasingly challenging to maintain a healthy workforce and to prevent early exit from paid employment. A concept that was developed to prevent early exit from paid employment is work ability.[1] According to Ilmarinen (2005), work ability is optimal when a worker’s resources and work demands are in balance.[1] Good work ability has been shown to be associated with higher work engagement[2], higher productivity at work[3], lower sickness absence[4], and lower risk of exit from the workforce through work disability[5]. To enable workers to enjoy a long and healthy working life, it is necessary to identify risk factors of poor work ability.

One factor that has repeatedly been identified as a risk factor of poor work ability is obesity (Body Mass Index (BMI) \(\geq 30\) kg/m\(^2\)) and, to a smaller extent, overweight (25 \(\leq\) BMI \(< 30\) kg/m\(^2\)).[6] There is little research on the causal pathways in the association between obesity and work ability. However, studies on work disability indicate that this effect may partly be due to the association of obesity with musculoskeletal disorders and cardiovascular diseases.[7, 8]

There are indications that the effects of obesity on work ability differ for workers with different levels of physical workload. First of all, high physical workload seems to have a negative effect on work ability[6], and, like obesity, the negative effect of high physical workload on work disability is mainly prevalent in workers with musculoskeletal disorders and cardiovascular disease.[7, 9] As both obesity and physical workload are found to be risk factors of the same types of diseases, it might be hypothesized that the effect of the combination of high physical workload with obesity is greater than the sum of their separate effects. In fact, Robroek et al. (under review) found a synergistic effect of obesity and high physical workload on the risk of work disability in construction workers.[8]

In order to improve our understanding of the role of physical workload in the relation between obesity and work ability, this study aimed to investigate whether physical workload moderates the relation between obesity and work ability. Based on earlier studies, we hypothesized that obesity, and to a lesser degree overweight, would have a stronger, negative
effect on work ability for workers with high physical workload than for those with low physical workload.

Methods

Study population and design
The study population of this longitudinal study consisted of Dutch construction workers who participated in at least two periodic medical examinations (PME), with one to seven years of follow-up, during the years 2008-2015. The PME was performed by occupational health services (OHS) throughout the country and consisted of a self-report questionnaire, physical examination, and blood analysis. PME participants consented to the utilization of the PME data for scientific purposes.

At the time of the study, it was estimated that about 50% of the construction workers were part of the collective labor agreement of the Dutch construction industry. These employees were invited periodically by the branch organization to participate in a PME. Construction workers aged 16 to 39 years were invited once every four years; workers aged 40 years or more were invited once every two years. Certain occupations, such as scaffolders, were invited on a yearly basis. The response level to the PME invitation was approximately 60%. Employees who had participated in at least one PME during the period 2008-2011 (baseline) and at least one PME during the period 2012-2015 (follow-up) were included in the sample.

In total, 57,044 employees in the construction industry participated in two PMEs. Administrative staff (n=18,860, 33.1%) were excluded, leaving 38,184 (66.9%) construction workers. Female construction workers (n=93, 0.2%) were excluded, as well as workers with less than one year between the baseline and follow-up measurement (n=96, 0.2%), and workers with incomplete information on work ability (n=120, 0.2%), BMI (n=11, 0.0%), physical workload (n=396, 0.7%), or other relevant variables (n=941, 1.6%). Since the study focused on overweight and obesity, underweight construction workers (BMI < 18.5 kg/m²; n=92, 0.2%) were also excluded. In total, 36,435 (63.9%) construction workers with complete information were included in the analyses.
Dependent variable

Work ability

Work ability was measured at follow-up using the work ability index (WAI), a self-reported measure consisting of seven dimensions: (1) perceived work ability (0-10), (2) perceived work ability given the physical and mental work demands (2-10), (3) diagnosed diseases (1-7), (4) sick leave in the previous 12 months (1-6), (5) perceived limitations in work due to disease (1-5), (6) prognosis of perceived work ability (1, 4, 7), and (7) perceived psychological resources (1-4). The summary score ranged from 7 to 49 and was dichotomized into poor/moderate (<37) and good/excellent (≥37) work ability.[1]

Independent variables

Overweight and obesity

To assess overweight and obesity, the BMI (kg/m²) was calculated from the biomedical measurements of body height and body weight, which were assessed at baseline and follow-up. The score was categorized according to WHO guidelines into underweight (BMI < 18.5 kg/m²), normal weight (18.5 ≤ BMI < 25.0 kg/m²), overweight (25.0 ≤ BMI < 30.0 kg/m²), and obesity (BMI ≥ 30.0 kg/m²). [10] The baseline and follow-up measurements of body height and body weight were used to calculate the change in BMI during that period.

Physical workload

Physical workload was measured using four dichotomous questions (yes/no), which were combined into two subscales: (1) strenuous work postures (“During your work, do you often have to work for a prolonged period of time in a kneeling, crouching, or uncomfortable position?”), and (2) manual material handling (“During your work, do you often have to lift, push, pull, or carry heavy loads?” and “During your work, do you often have to exert great force?”). A construction worker was considered having been exposed to high physical workload if he had answered ‘yes’ to at least one question belonging to that subscale.

Covariates

Based on previously identified associations with work ability[6, 11-13], confounding effects were tested for demographic, health-related and work-related characteristics. As demographic variables, age (continuous variable) and educational level (low, medium, high) were tested. As an indicator of health behavior, vigorous physical activity was included as a
covariate and was measured by a single question: respondents were considered vigorously physically active (yes/no), if they reported engaging “in vigorous physical activity (sports) that caused sweating and lasted at least 20 minutes” on at least three days per week. Smoking was assessed by a single question and categorized into never, former, or current smoker. As work-related factors, we included working hours (continuous) and psychosocial work demands. Based on the demand-control-support model[14] and the effort-reward model,[15] we combined nine dichotomous questions into the subscales (i) demands (n=2; time pressure, excess work), (ii) control (n=2; decide how to do the work, influence work speed), (iii) support (n=3; supported by supervisor, sphere at work, sufficient time for consultation), and (iv) rewards (n=2; feeling appreciated, sufficient reward). A respondent was considered exposed to high psychosocial work demands if he had answered ‘yes’ to at least one of the questions belonging to that subscale.

**Statistical Analysis**

Descriptive statistics were used to present baseline information on overweight and obesity, physical workload, and the potential confounders, as well as follow-up information on work ability. Binary logistic regression analyses were carried out to investigate the association of overweight at baseline, obesity at baseline, change in BMI between baseline and follow-up, and physical workload at baseline with poor/moderate work ability at follow-up. For overweight and obesity, the ‘normal weight’ group was used as reference. For physical workload, construction workers who reported low physical workload were used as reference. The odds ratio (OR) was used as indicator of the effect size. A covariate was included in the adjusted model if the OR of any of the variables BMI, change in BMI, overweight, obesity, manual material handling or strenuous work postures changed by more than 10%. Because information on educational level was measured in a subgroup, a sensitivity analysis was performed to test the confounding effect of educational level. The adjusted model was tested for effect modification. The additive effects of physical workload and overweight or obesity on work ability were analyzed using the relative excess risk due to interaction (RERI) and the corresponding 95% confidence interval, using the formula: RERI = OR (obesity + high physical workload) – OR (obesity + low/intermediate physical workload) – OR (normal weight + high physical workload) + 1. [16] A RERI greater than zero indicated a synergistic effect (more than additivity) and a RERI lower than zero indicated a negative interaction effect (less than additivity). Statistical analyses were carried out using IBM SPSS Statistics version 22.
Results

The study population consisted of 36,435 male construction workers with a mean age of 43.9 years (sd=9.8 years) at baseline. The mean follow-up duration was 3.3 years (sd=1.1 years), ranging from one to seven years. The mean BMI was 26.6 kg/m² (sd=3.6 kg/m²). Between the baseline and follow-up measurement, BMI increased on average with 0.3 kg/m² (sd=1.8 kg/m²). At baseline, 51% of the construction workers was overweight and 15% was obese (Table 2.1). In total, 60% of the construction workers were categorized as having been exposed to high physical workload. Younger employees (aged 16-30 years: 60%) were more likely to be having been exposed to manual material handling than older employees (aged 50-65 years: 48%). The construction workers had a mean WAI score of 40.6 (sd=5.5) at follow-up. In total, 18% had poor (n=1,032; 3%) or moderate (n=5,431, 15%) work ability. The mean BMI was higher among workers with poor/moderate work ability at follow-up (M=27.1, sd=3.6) than among those with good/excellent work ability (M=26.5, sd=3.6).

A higher BMI at baseline was related to poor/moderate work ability at follow-up (OR: 1.05, 95% CI: 1.04-1.05, Table 2.2). Also, an increase in BMI between baseline and follow-up was associated with poor/moderate work ability at follow-up (OR: 1.03, 95% CI: 1.01-1.05, Table 2.2); this association did not attenuate after adjustment for BMI at baseline (data not shown). After adjustment for age, the strength of the association between obesity and poor/moderate work ability attenuated from OR=1.57 (95% CI: 1.45-1.70) to OR=1.27 (95% CI: 1.17-1.38). Additional adjustment for health behaviors, work-related factors, or duration of follow-up did not further attenuate the relation between obesity and poor/moderate work ability (data not shown).

High physical workload was also associated with poor/moderate work ability (strenuous work postures: OR: 1.94, 95% CI: 1.83-2.04; manual material handling: OR: 1.54, 95% CI: 1.45-1.62, Table 2.2). Those workers exposed to high physical workload were more likely to have poor/moderate work ability at follow-up, irrespective of age at examination. Adjustment for the work-related factors demands, reward, and support led to attenuation of the risk of poor/moderate work ability for strenuous work postures (OR=1.80 (95% CI: 1.70-1.90). For manual material handling, adjustment for the work-related factors hardly changed the risk of poor/moderate work ability (OR=1.58; 95% CI: 1.49-1.68). Adjustment for health behaviors
or duration of follow-up did not influence the relation of physical workload with work ability (data not shown).

Table 2.1: Baseline characteristics of the total study population stratified by work ability at follow-up

<table>
<thead>
<tr>
<th>Work Ability</th>
<th>Poor/moderate</th>
<th>Good/excellent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>Follow-up duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2 years</td>
<td>1,249 (19)</td>
<td>5,449 (18)</td>
<td>6,698 (18)</td>
</tr>
<tr>
<td>3-4 years</td>
<td>4,495 (70)</td>
<td>21,592 (72)</td>
<td>26,087 (72)</td>
</tr>
<tr>
<td>5-7 years</td>
<td>719 (11)</td>
<td>2,931 (10)</td>
<td>3,650 (10)</td>
</tr>
<tr>
<td>Body weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Normal</td>
<td>Overweight</td>
<td>Obesity</td>
</tr>
<tr>
<td></td>
<td>1,857 (29)</td>
<td>3,430 (53)</td>
<td>1,176 (18)</td>
</tr>
<tr>
<td></td>
<td>10,641 (36)</td>
<td>15,041 (50)</td>
<td>4,290 (14)</td>
</tr>
<tr>
<td></td>
<td>12,498 (34)</td>
<td>18,471 (51)</td>
<td>5,466 (15)</td>
</tr>
<tr>
<td>Physical workload</td>
<td>Yes</td>
<td>Manual material handling</td>
<td>Yes</td>
</tr>
<tr>
<td>Strenuous work postures</td>
<td>3,448 (53)</td>
<td>11,129 (37)</td>
<td>14,577 (40)</td>
</tr>
<tr>
<td>Manual material handling</td>
<td>3,870 (60)</td>
<td>14,774 (49)</td>
<td>18,644 (51)</td>
</tr>
<tr>
<td>Demographic variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-29</td>
<td>277 (4)</td>
<td>3,876 (13)</td>
<td>4,153 (11)</td>
</tr>
<tr>
<td>30-39</td>
<td>551 (9)</td>
<td>5,295 (18)</td>
<td>5,846 (16)</td>
</tr>
<tr>
<td>40-49</td>
<td>2,122 (33)</td>
<td>11,699 (39)</td>
<td>13,821 (38)</td>
</tr>
<tr>
<td>50-64</td>
<td>3,513 (54)</td>
<td>9,102 (30)</td>
<td>12,615 (35)</td>
</tr>
<tr>
<td>Education&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>2,922 (91)</td>
<td>254 (8)</td>
<td>32 (1)</td>
</tr>
<tr>
<td></td>
<td>13,361 (87)</td>
<td>1,552 (10)</td>
<td>370 (2)</td>
</tr>
<tr>
<td></td>
<td>16,283 (88)</td>
<td>1,806 (10)</td>
<td>402 (2)</td>
</tr>
<tr>
<td>Health behaviors</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>1,910 (30)</td>
<td>11,831 (40)</td>
<td>13,741 (38)</td>
</tr>
<tr>
<td>Former</td>
<td>2,398 (37)</td>
<td>8,803 (29)</td>
<td>11,291 (31)</td>
</tr>
<tr>
<td>Current</td>
<td>2,155 (33)</td>
<td>9,338 (31)</td>
<td>11,493 (32)</td>
</tr>
<tr>
<td>Vigorous PA&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>5,414 (84)</td>
<td>24,560 (82)</td>
<td>29,974 (82)</td>
</tr>
<tr>
<td>Work-related factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>3,885 (60)</td>
<td>15,586 (52)</td>
<td>19,471 (53)</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>2,277 (35)</td>
<td>8,923 (30)</td>
<td>11,200 (31)</td>
</tr>
<tr>
<td>Support</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>1,375 (21)</td>
<td>3,652 (12)</td>
<td>5,027 (14)</td>
</tr>
<tr>
<td>Reward</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3,269 (51)</td>
<td>11,623 (39)</td>
<td>14,892 (41)</td>
</tr>
<tr>
<td>Working hours</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>&lt;40 h p/w</td>
<td>1,488 (23)</td>
<td>4,644 (16)</td>
<td>6,132 (17)</td>
</tr>
<tr>
<td>40 h p/w</td>
<td>4,023 (62)</td>
<td>19,849 (66)</td>
<td>23,872 (65)</td>
</tr>
<tr>
<td>&gt;40 h p/w</td>
<td>952 (15)</td>
<td>5,479 (18)</td>
<td>6,431 (18)</td>
</tr>
</tbody>
</table>

<sup>a</sup>BMI body mass index
<sup>b</sup>educational level had 17,944 missing cases (49.2%); variable was only used in the sensitivity analyses
<sup>c</sup>PA physical activity
Table 2.2: Relation of BMI and physical workload at baseline with poor/moderate work ability at followup (n=36,435)

<table>
<thead>
<tr>
<th>Weight</th>
<th>Univariate model</th>
<th>Poor/moderate work ability (n=6,463)</th>
<th>Adjusted for age</th>
<th>Adjusted for work-related factors(^a)</th>
<th>Fully adjusted model(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>BMI, continuous</td>
<td>1.05 (1.04-1.05)</td>
<td>1.03 (1.02-1.04)</td>
<td>1.04 (1.04-1.05)</td>
<td>1.03 (1.02-1.03)</td>
<td></td>
</tr>
<tr>
<td>BMI, T2-T1</td>
<td>1.03 (1.01-1.05)</td>
<td>1.06 (1.04-1.08)</td>
<td>1.03 (1.02-1.05)</td>
<td>1.06 (1.04-1.08)</td>
<td></td>
</tr>
<tr>
<td>Normal weight</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>1.31 (1.23-1.39)</td>
<td>1.10 (1.03-1.17)</td>
<td>1.29 (1.21-1.37)</td>
<td>1.09 (1.02-1.16)</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>1.57 (1.45-1.70)</td>
<td>1.29 (1.19-1.40)</td>
<td>1.53 (1.41-1.66)</td>
<td>1.27 (1.17-1.38)</td>
<td></td>
</tr>
<tr>
<td>Physical workload</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strenuous work postures</td>
<td>1.94 (1.83-2.04)</td>
<td>1.99 (1.88-2.11)</td>
<td>1.74 (1.64-1.84)</td>
<td>1.80 (1.70-1.91)</td>
<td></td>
</tr>
<tr>
<td>Manual material handling</td>
<td>1.54 (1.45-1.62)</td>
<td>1.75 (1.65-1.85)</td>
<td>1.38 (1.30-1.46)</td>
<td>1.58 (1.49-1.68)</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Adjusted for the work related factors demands, support, rewards

\(^b\)Adjusted for age and the work related factors demands, support, rewards; BMI and physical workload were not adjusted for each other

\(^c\)BMI body mass index
In the subgroup with information on educational level, adjusting for education only marginally reduced the association of continuous BMI, categorical BMI, BMI change, or physical workload with poor/moderate work ability (data not shown).

Table 2.3 shows that obesity in combination with strenuous work postures increased the risk of poor/moderate work ability more than the sum of the individual effects of obesity and strenuous work postures (RERI: 0.39, 95% CI: 0.10-0.67). Such a synergistic effect was also found for obesity and manual material handling (RERI: 0.26, 95% CI: 0.02-0.51). The synergistic effect of overweight and strenuous work postures, as well as the synergistic effect of overweight and manual material handling were weaker and not statistically significant (Table 2.3).

Table 2.3: Interaction effects of overweight and obesity with physical workload on poor/moderate work ability (n=36,435)*

<table>
<thead>
<tr>
<th></th>
<th>Poor/moderate work ability</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>OR (95%CI)</td>
<td>RERI (95%CI)</td>
</tr>
<tr>
<td><strong>Strenuous work postures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal weight, no strenuous work postures</td>
<td>7,383</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Normal weight, strenuous work postures</td>
<td>5,115</td>
<td>1.75 (1.57-1.94)</td>
<td></td>
</tr>
<tr>
<td>Overweight, no strenuous work postures</td>
<td>11,170</td>
<td>1.09 (1.00-1.20)</td>
<td></td>
</tr>
<tr>
<td>Overweight, strenuous work postures</td>
<td>7,301</td>
<td>1.95 (1.78-2.14)</td>
<td>0.10 (-0.09-0.29)</td>
</tr>
<tr>
<td>Obesity, no strenuous work postures</td>
<td>3,305</td>
<td>1.24 (1.10-1.40)</td>
<td></td>
</tr>
<tr>
<td>Obesity, strenuous work postures</td>
<td>2,161</td>
<td>2.37 (2.10-2.68)</td>
<td>0.39 (0.10-0.67)</td>
</tr>
<tr>
<td><strong>Manual material handling</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal weight, no manual material handling</td>
<td>5,922</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Normal weight, manual material handling</td>
<td>6,576</td>
<td>1.54 (1.39-1.71)</td>
<td></td>
</tr>
<tr>
<td>Overweight, no manual material handling</td>
<td>9,168</td>
<td>1.09 (0.99-1.21)</td>
<td></td>
</tr>
<tr>
<td>Overweight, manual material handling</td>
<td>9,303</td>
<td>1.71 (1.55-1.88)</td>
<td>0.05 (-0.11-0.22)</td>
</tr>
<tr>
<td>Obesity, no manual material handling</td>
<td>2,701</td>
<td>1.23 (1.08-1.40)</td>
<td></td>
</tr>
<tr>
<td>Obesity, manual material handling</td>
<td>2,765</td>
<td>2.04 (1.81-2.30)</td>
<td>0.26 (0.02-0.51)</td>
</tr>
</tbody>
</table>

*Adjusted for age, as well as the work-related factors demands, support, and rewards
Discussion

Main findings

Construction workers with obesity and, to a lesser degree, overweight, were at an increased risk of poor/moderate work ability. An increase in BMI over time accounted for additional excess risk of poor/moderate work ability, regardless of the prior body weight status. Those workers who were exposed to high physical workload were also at an increased risk of poor/moderate work ability. As hypothesized, the combination of obesity with high physical workload had a greater effect on poor or moderate work ability than the sum of the individual effects. No significant synergistic effect was found for the combination of overweight and high physical workload. Exposure to strenuous work postures had a greater synergistic effect than exposure to manual material handling.

Comparison with previous studies

The finding that obesity was associated with poor work ability is in line with a systematic review[6] and a recent study based on a Finnish birth cohort with measurements at the ages 31 and 46 years (n=5,654), which reported a negative effect of overweight and obesity on work ability in both men and women beyond the effect of different demographic, work-related, and lifestyle factors, including leisure time physical activity[11]. Contrary to our findings, Laitinen et al. (2005) found no effect of overweight/obesity on work ability in men in the same Finnish birth cohort measured at the ages 14 and 31.[17] However, the study did find a negative effect of overweight/obesity on work ability in women, and of high waist-hip ratio in both men and women. The null association in men found in that study might have been due to the fact that BMI was partially assessed through self-report, and men might have reported differently than women[18]. On the other hand, the study by Laitinen et al. was based on a birth cohort, while this study was based on construction workers, which might explain the difference in findings.

The negative effect of obesity on work ability can partly be explained by their association with specific health conditions, particularly with musculoskeletal disorders and cardiovascular diseases.[7, 8] The increased prevalence of musculoskeletal disorders in those with obesity is commonly attributed to mechanisms that include reduced balance, muscle strength (relative to body weight), muscle endurance, spine flexibility, physiological range of motion in the joints, as well as increased mechanical load on weight bearing joints, and low level
inflammations.[20, 21] These factors are likely to limit a workers functional performance and thereby increase the risk of musculoskeletal injury and disorders. Obesity increases the risk of cardiovascular diseases through numerous physiological changes, including its effect on hypertension, glucose intolerance, and low level inflammation.[19] This study was not able to disentangle the effects of obesity and poor health on work ability. Future studies might investigate whether obesity has an effect on work ability that is independent of poor health.

The association of high physical workload with poor work ability is well researched[6, 22, 23], and our findings confirm this association. The association of high physical workload with poor work ability can also be partially attributed to its association with musculoskeletal disorders[7, 8, 22, 24] and cardiovascular diseases[7, 8]. Central to the association between physical workload and musculoskeletal or cardiovascular disorders is physical capacity. If physical workload exceeds a worker’s physical capacity, and if there is insufficient opportunity for recovery, this will over time lead to complaints in the musculoskeletal and cardiovascular system.[25] It is often believed that high physical workload has a training effect on physical capacity, which would buffer negative health effects. Especially regarding construction workers, this is a common assumption. However, a study among the Swedish working population (N=188) showed that workers do not necessarily adapt to physical work demands; of the 188 men and women studied, 25% exceeded the recommended maximum work intensity of 30% VO\textsubscript{max}.[26] Krause et al. (2015) demonstrated that physical workload even below this commonly used threshold can have harmful effects.[27] Overexertion is in fact among the most common causes for musculoskeletal disorders in construction work[28], highlighting the potentially harmful effects of physical activity. It appears that the effect of physical activity depends on its characteristics: Holtermann et al. (2012) showed that physical activity during leisure time had a protective effect, while physical activity at work had the opposite effect.[29] These studies indicate the importance of understanding the effects of different types, intensities and durations of occupational physical activity, which up to now are insufficiently studied.

Studies that describe the effects of specific types of physical workload on work ability are scarce. The few other studies that specify the effects of manual material handling and strenuous work postures confirm our finding that the effect of strenuous work postures on work ability is greater than that of manual material handling, although the differences were
small.[12, 30-33] The different effect sizes might be explained by strenuous work postures affecting the entire body, while manual material handling only affects specific body sites, leading to an accumulation of physical strain. However, our understanding of underlying mechanisms is still limited[21], and studies that disentangle differential effects of specific types of physical load are needed in order to devise interventions targeting specific types of tasks.

To our knowledge, there are no other longitudinal studies that tested the interaction effect of obesity and physical workload on work ability. Based on a cross-section analysis, Nevanpera et al. (2015) found a lower risk of poor work ability in obese men at the age of 46 years with high physical workload than in men with low physical workload.[11] The inconsistency of results of the Finnish study and the current study might be due to different characteristics of the study population, to adjustment for different covariates, and to a different measurement method of physical workload. However, our findings are in line with a study on work disability, which reported a synergistic effect of overweight and physical workload, as well as obesity and physical workload, on risk of work disability due to musculoskeletal disorders.[8] The synergistic effect of obesity and high physical workload largely follows from the negative effects of obesity on physical capacity. The debilitating effect of obesity on cardiorespiratory and musculoskeletal capacity makes a worker less well equipped to deal with high physical workload.

**Implications**

Taking into account that obesity and high physical workload increase the risk of poor work ability, interventions that promote body weight loss and increasing a worker’s physical capacity might have a positive effect on work ability. A study by Korshoj et al. (2016) showed that aerobic exercise successfully increased the cardiorespiratory fitness in a group of cleaners (N=116) and had a positive effect on several markers of cardiovascular risk.[34] However, an adverse intervention effect on blood pressure was detected among those participants with a high relative aerobic workload, indicating the need to further develop such interventions. Considering the high prevalence of musculoskeletal and cardiovascular disorders among construction workers, exercise programs would have to be tailored to the capacities and limitations of the target group. Groeneveld et al. demonstrated a positive effect of a lifestyle intervention based on a healthy diet and physical activity on body weight and on
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Risk factors of cardiovascular disease in construction workers.[34, 35] However, implementation of such interventions has proven difficult with generally low participation and compliance [36, 37]. In addition, employers appear reluctant to interfere with their employees’ lifestyle.[38] Tailoring the physical workload to the physical capacity of an individual workers might be an alternative way to take into account the negative effect of obesity on physical capacity.

Strengths and limitations
This study is one of the few to investigate the combined effect of obesity and physical workload on work ability. The strength of the study lies in its longitudinal design, the large sample size, and the confounders the study controlled for. Although the study had a longitudinal design, analysis of two measurements in time does not allow for drawing conclusions about causality. To investigate causal relationships, a study is needed that relates a change in body weight status to a later change in work ability. In the interpretation of the findings, it needs to be considered that the study population did not include construction workers who left the workforce due to work disability, unemployment, or early retirement. Therefore, the study might have underestimated the effect of obesity and physical workload on poor/moderate work ability. However, since there was considerable variation in the included variables, the bias caused by an eventual selection should be limited. Although body weight was assessed during a physical examination, other variables, including physical workload, were measured by self-report, which has lower validity than for example objective measures.[39] Obese workers may experience physical tasks as more strenuous than workers with a normal body weight, which might have led them to overreport exposure to high physical workload. Overreporting may lead to an overestimation of the interaction between obesity and physical workload. Vigorous physical activity, a potential confounder tested in this study, was also measured by questionnaire and inquired about both physical activity at work and during leisure time. These two types of behavior have been shown to have opposite effects on health [29], which might explain our finding that vigorous physical activity did not influence the association of obesity and physical workload with poor/moderate work ability.

[29] This study used BMI to assess obesity, which has been found an inferior indicator of body fatness than for example waist-to-hip ratio. Especially in physically active individuals, an above average proportion of muscle mass might lead to a misclassification as obese.[40] Therefore, the obesity-work ability association might have been underestimated in this study.
However, while BMI is considered suboptimal for diagnosing obesity at the individual level, it is still considered a useful indicator of obesity at the population level. [41]

**Conclusion**

Obesity and high physical workload increased the risk of a poor or moderate work ability, especially when they occurred in combination with each other. Our results indicate a potential beneficial effect on work ability of interventions that decrease obesity and physical workload.
References


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