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Original research

# Effects of consecutive workdays and days off on low back pain, fatigue and stress: prospective cohort study among warehouse and construction workers

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## ABSTRACT

**Objectives** Limited knowledge exists about day-to-day changes in physical and mental symptoms in warehouse and construction workers. This study investigated the associations between consecutive workdays and days off with low back pain (LBP) intensity, bodily fatigue and mental stress.

**Methods** Participants (n=224) received daily questions for 21 days about LBP, fatigue, stress (outcome, 0–10 scales), and workdays and days off (exposure). We tested associations between 1–3 workdays (n=148) and 1–2 days off (n=158) with LBP intensity, bodily fatigue and mental stress after work and the following morning using linear mixed models with repeated measures controlling for relevant confounders.

**Results** Consecutive workdays led to progressively increased LBP intensity, with three workdays increasing LBP intensity by 1.76 (95% CI 1.48 to 2.03) points. Bodily fatigue and mental stress increased after one workday (2.06 (95% CI 1.80 to 2.32) and 0.97 (95% CI 0.77 to 1.17) points, respectively) and remained stable for three workdays. After 1 day off, bodily fatigue and mental stress decreased –1.82 (95% CI –2.03 to –1.61) and –0.88 (95% CI –1.05 to –0.71) points, respectively, without decreasing further. In contrast, LBP intensity decreased progressively –1.09 (95% CI –1.27 to –0.91) and –1.45 (95% CI –1.67 to –1.24) points after 1 and 2 days off, respectively.

**Conclusions** Workdays and days off affected the outcome variables differently. LBP intensity progressively increased with consecutive workdays, while workers needed 2 days off to recover. This study provides valuable knowledge about how to organise the workweek to prevent LBP, fatigue and stress, potentially reducing labour market withdrawal.

## INTRODUCTION

Both physical and psychosocial work demands are important determinants of worker health and well-being.<sup>1</sup> Physically demanding work increases the risk of experiencing physical and psychosocial symptoms, such as musculoskeletal disorders (MSD),<sup>2,3</sup> bodily fatigue<sup>4,5</sup> and mental stress.<sup>6</sup> In turn, such symptoms may decrease work ability<sup>7</sup> and prove costly for workplaces and society due to decreased productivity (presenteeism)<sup>8</sup> and increased risk of sickness absence.<sup>7,9,10</sup> Furthermore, a study among compensation claimants observed a delayed return to work among workers with psychological injuries compared with those affected by musculoskeletal

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Warehouse and construction work includes heavy and frequent lifting work, which is associated with increased low back pain (LBP) intensity, bodily fatigue and mental stress. To better organise working weeks, knowledge is needed about the association of consecutive workdays and days off on the development of these symptoms.

## WHAT THIS STUDY ADDS

⇒ Consecutive workdays led to progressively increased LBP intensity in warehouse and construction workers, while two consecutive days off were needed to recover from the accumulated LBP from the preceding workdays. Bodily fatigue and mental stress increased on consecutive workdays and decreased to baseline levels after 1 day off.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study provides practical knowledge about how to optimise combinations of workdays and days off to prevent adverse physical and mental health effects. These data may instigate initiatives at workplaces to ensure sufficient rest periods for workers to recover between physically demanding job tasks.

injuries,<sup>11</sup> which underlines the importance of taking both physical and psychological/psychosocial work demands into account.

Poor psychosocial working conditions are known to increase the risk of developing low back pain (LBP).<sup>12</sup> Further, joint associations between physical and psychosocial working conditions may elevate the risk of long-term sickness absence.<sup>13</sup> Notably, work-related MSD has been estimated to reduce the gross domestic product in European countries by up to 2%.<sup>8</sup> In Denmark, LBP results in a yearly productivity loss of ~€2.7 billion due to temporary and permanent exits from the labour market as well as earlier death compared with people without LBP.<sup>14</sup> Thus, increased knowledge about physical and psychosocial job demands should be considered a priority to ensure worker well-being.<sup>1,12,13</sup>

Warehouse and construction work is physically demanding and consists of frequent and heavy lifting.<sup>15,16</sup> However, we lack knowledge about



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day-to-day changes in physical and mental symptoms, such as LBP, fatigue and stress, during workdays and days off from work. Among supermarket workers, consecutive workdays increased LBP intensity in an exposure-response manner, while LBP intensity decreased to 'baseline' levels after 1 day off.<sup>17</sup> To a large extent, warehouse and supermarket workers manually handle the same merchandise although warehouse workers typically have higher daily lifting volumes. Thus, the above observations in supermarket workers may not be representative of warehouse workers. Because warehouse and construction work is among the most physically demanding job groups,<sup>16</sup> and construction work is associated with physical and mental symptoms,<sup>18</sup> increased knowledge about day-to-day changes in physical and mental work-related factors may allow to better organise the working week to maintain or improve worker well-being and productivity. However, although psychological injuries seem to be more detrimental than musculoskeletal injuries in terms of return to work,<sup>11</sup> the fact that warehouse and construction workers are scoring relatively higher on ergonomic exposures<sup>16</sup> than psychosocial factors<sup>19</sup> may cause day-to-day fluctuations in physical symptoms (LBP intensity and bodily fatigue) to exceed the corresponding variations in the psychosocial symptoms (mental stress).

This study investigated the association of one, two and three consecutive workdays with LBP intensity, bodily fatigue and mental stress among warehouse and construction workers. The same associations were tested with 1 and 2 days off from work. The primary hypothesis was that LBP intensity would increase progressively during consecutive workdays.<sup>20</sup> Second, it was hypothesised that: (1) bodily fatigue and mental stress would increase with consecutive workdays, (2) workers would need two consecutive days off from work to recover from the accumulated LBP and fatigue and (3) 1 day off would be sufficient to recover from mental stress. Because warehouse and construction workers score relatively higher on ergonomic exposures than psychosocial factors, we hypothesised that the present study population would recover faster from mental stress than from physical symptoms.

## METHODS

### Study design

This 3-week prospective cohort study investigated day-to-day changes in physical and mental symptoms among warehouse and construction workers. Compared with the study protocol,<sup>20</sup> recruitment challenges and the COVID-19 pandemic from 2020 to 2022 resulted in several amendments (cf online supplemental material). This study used short twice-daily questionnaires to investigate the associations between consecutive workdays and

days off (exposure) with LBP intensity, bodily fatigue and mental stress (outcome). Two weeks before the 3-week period, participants responded a baseline questionnaire about the working environment, general characteristics, lifestyle and health. The 3-week period spanned from May 2021 to March 2022. The study follows the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.<sup>21</sup> Figure 1 depicts the study flow chart.

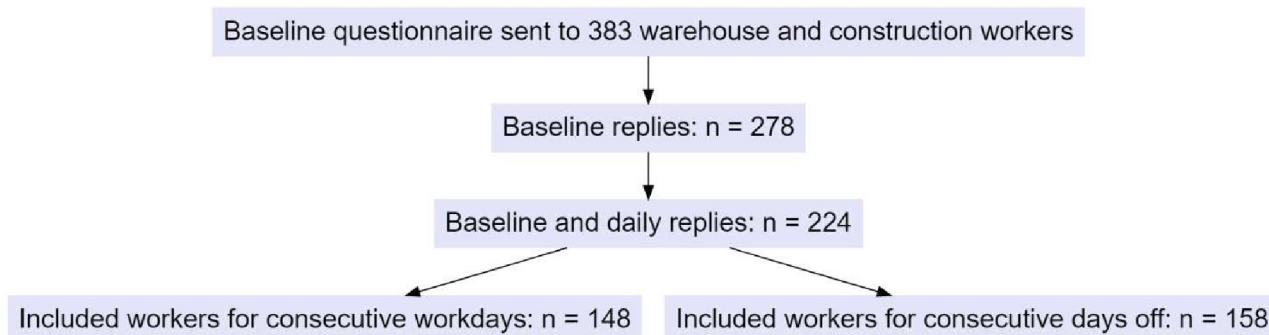
### Participants

We invited 383 warehouse and construction workers to participate in the study, with 278 respondents (response rate: 72.6%) completing the baseline questionnaire (figure 1). Eligible participants met the following criteria: (1) worked  $\geq 30$  hours/week in a retail industry warehouse or at a construction site involving lifting tasks, (2)  $\geq 18$  years old, (3) could read and understand Danish or English and (4) replied the baseline questionnaire and daily questionnaires. The study included 148 workers examining the effects of consecutive workdays and 158 investigating the effects of consecutive days off. The number of included workers varies due to individual missing responses. Participants were employed at 13 different warehouse terminals across 10 retail chains and six different construction sites involving three companies in Denmark. Worksite leaders provided contact information for interested employees involved in lifting work. Subsequently, we invited the workers to complete the web-based baseline questionnaire and participate in the 3-week survey via short message service (SMS) text messages. Before inviting the workers, the leaders provided participants' working schedules.

### Ethical aspects

According to Danish legislation, scientific questionnaire studies are exempt from ethical or scientific committee approval and informed consent from participants. Data collected were stored securely on a server at the research institution and handled anonymously. Before data analysis, a data manager anonymised the data. The project is registered at the Danish Data Protection Agency.

Workers received written and oral information about the project before receiving the baseline questionnaire. The SMS message accompanying the questionnaire included a brief description and a web link to access the online questionnaire. The initial page of the questionnaire contained a comprehensive project description, information regarding participants' rights and contact details for the project leader.



**Figure 1** Study flow chart comprising the total subject samples.

### Workdays and days off from work (exposure)

After each workday, participants received the question, 'How many hours have you been at work today? Type a number between 0 and 15. Type 0 if you have not been at work'. Thus, 0 represented a day off from work while answers above 0 represented having attended work that day. The participants received the question at the same time point each day (also on days off), being a part of the daily questionnaire comprising the outcome measures after work (see next section).

### LBP, fatigue and stress (outcome)

Daily web-based questionnaires on LBP intensity, bodily fatigue and mental stress were sent via SMS text messages using the web-based survey platform SurveyXact. Workers received the questionnaires in 12-hour intervals for 21 days: 'after the workday' (eg, 19:00) and 'the following morning' (eg, 07:00), both on workdays and days off. The time schedules were based on the participants' working schedules.

LBP intensity was assessed on a 0–10 numeric rating scale (NRS) by asking, 'How much pain do you experience in your low back this morning?', with 0 indicating 'no pain at all' and 10 indicating 'worst imaginable pain'.<sup>22</sup> Bodily fatigue was also assessed using the NRS–Fatigue scale of 0–10 with the question, 'How tired are you in the body this morning?' Participants responded by selecting a number between 0 and 10, where 0 represented 'not tired at all' and 10 represented 'completely exhausted'.<sup>23 24</sup> Likewise, day-to-day changes in mental stress were assessed using a 0–10 NRS with the question, 'How stressed do you feel this morning?', where 0 indicated 'not stressed at all' and 10 indicated 'maximally stressed'. In the morning, the questions ended with '... this morning', while after the workday, the questions ended with '... this evening'.

### Potential confounders

We provide minimally and fully adjusted models, adjusting the analysis for relevant confounders. In the minimally adjusted models, we adjusted for sex (categorical: man/woman), age (continuous), employment with lifting work (continuous), job title (categorical), LBP intensity during the past 4 weeks prior to study onset (continuous, NRS 0–10), chronic LBP (categorical: yes/no) and perceived stress within the last 2 weeks prior to study onset (categorical: 'All the time', 'Often', 'Sometimes', 'Rarely', 'Never'). The fully adjusted models comprised additional adjustments for the following lifestyle and work-related factors: smoking (categorical: yes/no), leisure-time physical activity (categorical: sedentary, light, moderate, vigorous), body mass index (BMI, kg/m<sup>2</sup>, continuous), influence at work (categorical), access to necessary work tools (categorical), role clarity (categorical), guidance (categorical), community and cohesion between colleagues (categorical), recognition (categorical), respectful relationship between leader and employees (categorical) and fairness (categorical). The response options for influence at work, access to necessary work tools, role clarity, guidance, community and cohesion, recognition, respectful relationship and fairness were: 'To a very large extent', 'To a large extent', 'Somewhat', 'To a small extent' and 'To a very small extent'.

### Statistical analyses

Associations of working schedule with reported symptoms were tested using the linear mixed models with repeated measures (Proc Mixed, SAS V.9.4, SAS Institute). Participants were nested within clusters as a random factor to account for intragroup correlations.

In the first analysis, the working schedule was taken into account by considering the number of consecutive workdays as a class variable with categories: reference values 0 (at least two consecutive days off), 1 (one workday after at least two consecutive days off), 2 (two consecutive workdays after at least two consecutive days off) and 3 (three consecutive workdays after at least two consecutive days off).

In the second analysis, the working schedule was taken into account by considering the number of consecutive days off from work as a class variable with categories: reference values 0 (at least three consecutive workdays), 1 (1 day off after at least three consecutive workdays) and 2 (two consecutive days off after at least three consecutive workdays).

The outcome variables analysed as continuous variables were LBP intensity, bodily fatigue and mental stress after work and the following morning/day before work, depending on the specific working schedule. The estimation model used the restricted maximum likelihood with df based on Satterthwaite approximation. The results are reported as least squares means (LSM), and differences in LSM along with their 95% CIs compared with day 0. An alpha level of  $p < 0.05$  was considered statistically significant.

## RESULTS

Mean age was 39.5 (SD±12.3) years, and the majority were warehouse workers and men with a mean BMI of 26.7 kg/m<sup>2</sup> (table 1). They reported a mean LBP intensity at 4.8 (SD 2.7) points and 43.3% reported chronic LBP during the past 3 months. Lastly, more than half the workers had felt stressed within the past 2 weeks before replying the baseline questionnaire.

### Low back pain

#### Workdays

LBP increased with consecutive workdays (table 2A). In the fully adjusted model, mean LBP intensity was 2.09 (95% CI 1.33 to 2.86) points at the 'after the workday' time point at 0 workday. Following one and two consecutive workdays, LBP intensity increased by 1.34 (95% CI 1.11 to 1.57) and 1.33 (95% CI 1.07 to 1.58) points, respectively (table 2A), while LBP intensity increased by 1.76 (95% CI 1.48 to 2.03) points following three consecutive workdays.

In both models, consecutive workdays were associated with increased LBP intensity the following morning compared with the mornings following 0 workday (table 2A). No differences existed between the mornings following one, two or three workdays.

#### Days off from work

One and 2 days off led to decreased LBP intensity at the 'after the workday' time point compared with 0 day off (table 2B). From an LBP intensity at 2.74 (95% CI 1.99 to 3.49) points 'after the workday' at 0 day, LBP intensity decreased by -1.09 (95% CI -1.27 to -0.91) points after 1 day off and -1.45 (95% CI -1.67 to -1.24) points after two consecutive days off.

LBP intensity remained lower the morning following 1 and 2 days off from work (table 2B), while LBP intensity tended to be lower in the morning following 2 days off compared with the morning following 1 day off (minimally adjusted model:  $p = 0.079$ , fully adjusted model:  $p = 0.070$ ).



**Table 1** Participant characteristics

	n	%	Mean	SD
Age	158		39.5	12.3
Job group				
Warehouse workers	133	84.2		
Construction workers	25	15.8		
Sex	157			
Men		73.9		
Women		26.1		
BMI (kg/m <sup>2</sup> )	158		26.7	5.1
Smoking	157			
Yes		31.8		
No		68.2		
Physical activity during leisure time	157			
Sedentary activities		25.5		
Light activities ≥4 hours/week		49.0		
Moderate activities ≥4 hours/week		18.5		
Vigorous exercise several times/week		7.0		
Work ability (0–10)	158		7.9	1.6
Physically demanding work (0–10)	158		6.8	1.9
Employment (years)	158		12.3	12.2
Low back pain intensity at baseline (0–10)	158		4.8	2.7
Chronic low back pain	157			
Yes		43.3		
No		56.7		
Stress within the past 2 weeks at baseline	157			
All the time		3.2		
Often		18.5		
Sometimes		29.9		
Rarely		30.6		
Never		18.8		
Working hours/workday	158		8.3	2.0

Some variables have missing values.  
n indicates sample size.  
BMI, body mass index.

## Bodily fatigue

### Workdays

Both models showed workdays to be associated with increased bodily fatigue ‘after the workday’ (table 3A). From 2.39 (95% CI 1.57 to 3.21) points after 0 workday in the fully adjusted model, bodily fatigue increased by 2.06 (95% CI 1.80 to 2.32), 1.83 (95% CI 1.55 to 2.12) and 2.14 (95% CI 1.83 to 2.44) points after one, two and three consecutive workdays, respectively. No difference in bodily fatigue existed between workdays, except for a tendency towards lower bodily fatigue after two consecutive workdays compared with three (minimally adjusted model:  $p=0.093$ , fully adjusted model:  $p=0.097$ ).

In both models, bodily fatigue remained elevated the morning after each consecutive workday (table 3A) without any difference between consecutive workdays.

### Days off from work

Bodily fatigue decreased on days off from work at both the ‘after the workday’ and ‘following morning’ time points, with no differences between 1 and 2 days off (table 3B). From 4.20 (95% CI 3.43 to 4.96) points ‘after the workday’ at 0 day off in the fully adjusted model, bodily fatigue decreased by  $-1.82$  (95% CI  $-2.03$  to  $-1.61$ ) points after 1 day off and did not decrease further after 2 days off.

## Mental stress

### Workdays

Workdays resulted in increased mental stress after work (table 4A), with no differences between the number of consecutive workdays. In the fully adjusted model, mean mental stress ‘after the workday’ at 0 workday was 1.16 (95% CI 0.30 to 2.01) points. Following one, two and three consecutive workdays, mental stress increased by 0.97 (95% CI 0.77 to 1.17), 1.12 (95% CI 0.89 to 1.34) and 1.08 (95% CI 0.84 to 1.32) points, respectively.

Mental stress remained elevated the following morning after workdays compared with 0 workday, with no differences between the number of workdays (table 4A).

### Days off from work

Days off from work resulted in decreased mental stress at the ‘after the workday’ time point (table 4B), with no difference between 1 and 2 days off. From 1.76 (95% CI 0.95 to 2.57) points at 0 workday, mental stress decreased by  $-0.88$  (95% CI  $-1.05$  to  $-0.71$ ) and  $-1.01$  (95% CI  $-1.21$  to  $-0.81$ ) points after 1 and 2 days off, respectively.

In the ‘following morning’ time point following 1 day off, mental stress remained lower compared with 0 day off (table 4B). Mental stress did not reach statistical significance in the ‘following morning’ time point after 2 days off compared with the morning after 0 day off.

## DISCUSSION

The present study revealed that consecutive workdays resulted in increased LBP intensity after work, while (at least) two consecutive days off from work were needed to recover from the accumulated LBP intensity from the preceding workdays. Bodily fatigue and mental stress increased after one workday and remained elevated for three consecutive workdays, while 1 day off was sufficient to decrease bodily fatigue and mental stress. Additionally, LBP intensity, bodily fatigue and mental stress remained elevated the morning after a preceding workday.

## Low back pain

The present study elaborates on previous findings that LBP intensity progressively increases with consecutive workdays among supermarket workers.<sup>17</sup> In the present study, three consecutive workdays resulted in more intense LBP than one and two workdays, exceeding a minimal clinically important difference.<sup>25</sup> Although the present increases of 1.34–1.76 NRS points after work may appear small, such mean day-to-day increases ~12–16% are considered highly clinically significant.<sup>25</sup> Because individual changes of ≥10% or 1.0 score points are considered as minimal clinically important differences,<sup>25</sup> mean changes above these values are particularly meaningful, given that this indicates a substantial proportion of the participants to demonstrate even larger changes. Furthermore, LBP intensity remained elevated the following morning, that is, workers started work the following day with heightened LBP. Notably, they experienced considerable LBP, with mean intensity ranging from 2.09 to 3.85 across 0–3 workdays, respectively (table 2A), and 43.3% reported chronic LBP (table 1). These reported LBP intensities align with levels known to reduce work ability<sup>7</sup> and increase the risk of long-term sickness absence.<sup>7, 26</sup> Thus, the study findings provide valuable day-to-day insights into the progression of LBP during consecutive workdays.

Consecutive days off gradually decreased LBP intensity at the ‘after the workday’ time point, reaching a clinically important

**Table 2** Associations between number of consecutive workdays and days off from work and change in low back pain (LBP) intensity after work and the following morning presented in minimally and fully adjusted models

	Minimally adjusted model		Fully adjusted model	
	LSM	LSM differences	LSM	LSM differences
	Estimates	Difference (95% CI)	Estimates	Difference (95% CI)
<b>(A) Workdays</b>				
<b>After the workday</b>				
0–3 workdays				
0	1.79	Reference	2.09	Reference
1	3.14	1.35 (1.12 to 1.58)*	3.44	1.34 (1.11 to 1.57)*
2	3.13	1.33 (1.08 to 1.59)*	3.42	1.33 (1.07 to 1.58)*
3	3.56	1.77 (1.49 to 2.04)*†	3.85	1.76 (1.48 to 2.03)*†
<b>The following morning</b>				
0–3 workdays				
0	1.73	Reference	1.91	Reference
1	2.56	0.83 (0.61 to 1.05)*	2.74	0.83 (0.60 to 1.05)*
2	2.58	0.85 (0.61 to 1.09)*	2.77	0.85 (0.61 to 1.09)*
3	2.59	0.86 (0.60 to 1.12)*	2.77	0.86 (0.60 to 1.12)*
<b>(B) Days off work</b>				
<b>After the workday</b>				
0–2 days off				
0	2.51	Reference	2.74	Reference
1	1.43	−1.09 (−1.27 to −0.91)‡	1.65	−1.09 (−1.27 to −0.91)‡
2	1.06	−1.45 (−1.66 to −1.23)‡§	1.28	−1.45 (−1.67 to −1.24)‡§
<b>The following morning</b>				
0–2 days off				
0	2.12	Reference	2.17	Reference
1	1.65	−0.47 (−0.64 to −0.30)‡	1.69	−0.47 (−0.64 to −0.30)‡
2	1.43	−0.69 (−0.91 to −0.48)‡¶	1.46	−0.70 (−0.92 to −0.48)‡¶

(A) represents associations between consecutive workdays (0–3 workdays) and change in LBP intensity after the working day and the following morning, while (B) represents associations between consecutive days off (0–2 days off) and change in LBP intensity at time points 'after the workday' and 'the following morning'. Minimally adjusted model: adjusted for age, sex, years of employment, job title, LBP intensity the preceding 4 weeks prior to baseline, chronic LBP and perceived stress during the 2 weeks before baseline. Fully adjusted model: minimally adjusted model+smoking, leisure-time physical activity, body mass index (BMI), influence at work, access to work tools, role clarity, guidance, community and cohesion between colleagues, recognition, respectful relationship between leader and employees, and fairness. \*Statistically significantly different from 0 workday (reference). †Statistically significantly different from 2 consecutive workdays. ‡Statistically significantly different from 0 day off (reference). §Statistically significantly different from 1 day off. ¶Tendency towards a statistically significant difference from 1 day off (minimally adjusted model:  $p=0.079$ , fully adjusted model:  $p=0.070$ ). LSM, least squares means.

difference.<sup>25</sup> Additionally, LBP intensity tended to be lower in the morning following two consecutive days off compared with 1 day off ( $p=0.070$ ) (table 2B). While LBP intensity did not further decrease after 1 day off among supermarket workers,<sup>17</sup> our data suggest that warehouse and construction workers may need (at least) 2 days off to recover from the progressive increase in LBP intensity during the preceding workdays. Given that LBP increases the risk of labour market withdrawal<sup>26 27</sup> with associated costs for employees, employers and society,<sup>8 14</sup> targeted workplace initiatives are vital for reducing LBP prevalence and severity, and improving musculoskeletal health while maintaining productivity.

### Bodily fatigue

Participants reported an increase of ~2 points in bodily fatigue after work, and bodily fatigue remained ~1 point higher the following morning, indicating that workers attended work on consecutive workdays more fatigued than following a day off. Furthermore, mean changes in fatigue of above 1 point in a

0–10 NRS are considered as a minimal important difference.<sup>28</sup> As for the day-to-day changes in LBP intensity, the present mean change of 1–2 NRS points in bodily fatigue indicates that some participants have experienced even greater increases in fatigue, as also manifested by the 95% CIs (cf table 3). The mean bodily fatigue values of ~4.5 points after a workday indicate significant fatigue among the study participants acutely after completing their workday (cf table 3). Previous research has demonstrated that physically demanding work is associated with higher levels of perceived fatigue and exertion,<sup>4 5 29</sup> which can lead to reduced worker productivity (presenteeism)<sup>8</sup> and serve as a predictor of future sickness absence.<sup>10</sup>

Additionally, fatigue may be associated with pain,<sup>30</sup> and workers affected by neck/shoulder pain tend to be more fatigued than pain-free workers.<sup>31</sup> Comparably, our findings reveal that warehouse and construction workers, who report significant fatigue, also experience prevalent and intense LBP. While previous findings have shown an increase in fatigue from work to leisure time,<sup>31</sup> our data conversely demonstrate a decrease in

**Table 3** Associations between number of consecutive workdays and days off from work and change in bodily fatigue after work and the following morning presented in minimally and fully adjusted models

	Minimally adjusted model		Fully adjusted model	
	LSM Estimates	LSM differences Difference (95% CI)	LSM Estimates	LSM differences Difference (95% CI)
<b>(A) Workdays</b>				
<b>After the workday</b>				
0–3 workdays				
0	2.26	Reference	2.39	Reference
1	4.33	2.07 (1.81 to 2.33)*	4.45	2.06 (1.80 to 2.32)*
2	4.10	1.84 (1.56 to 2.13)*†	4.23	1.83 (1.55 to 2.12)*†
3	4.41	2.15 (1.84 to 2.45)*	4.53	2.14 (1.83 to 2.44)*
<b>The following morning</b>				
0–3 workdays				
0	2.02	Reference	2.02	Reference
1	3.07	1.05 (0.81 to 1.29)*	3.07	1.05 (0.80 to 1.29)*
2	2.93	0.91 (0.65 to 1.17)*	2.92	0.91 (0.64 to 1.17)*
3	3.03	1.01 (0.73 to 1.29)*	3.02	1.00 (0.72 to 1.29)*
<b>(B) Days off work</b>				
<b>After the workday</b>				
0–2 non-workdays				
0	4.14	Reference	4.20	Reference
1	2.32	–1.82 (–2.02 to –1.61)‡	2.38	–1.82 (–2.03 to –1.61)‡
2	2.15	–1.99 (–2.24 to –1.75)‡	2.20	–2.00 (–2.25 to –1.75)‡
<b>The following morning</b>				
0–2 non-workdays				
0	3.33	Reference	3.31	Reference
1	2.37	–0.95 (–1.16 to –0.75)‡	2.35	–0.95 (–1.16 to –0.75)‡
2	2.30	–1.03 (–1.30 to –0.77)‡	2.27	–1.04 (–1.31 to –0.77)‡

(A) represents associations between consecutive workdays (0–3 workdays) and change in fatigue after work and the following morning, while (B) represents associations between consecutive days off (0–2 days off) and change in bodily fatigue at the ‘after the workday’ and ‘the following morning’ time points.  
Minimally adjusted model: adjusted for age, sex, years of employment, job title, low back pain (LBP) intensity the preceding 4 weeks prior to baseline, chronic LBP and perceived stress during the 2 weeks before baseline.  
Fully adjusted model: minimally adjusted model+smoking, leisure-time physical activity, body mass index (BMI), influence at work, access to work tools, role clarity, guidance, community and cohesion between colleagues, recognition, respectful relationship between leader and employees, and fairness.  
\*Statistically significantly different from 0 workday (reference).  
†Tendency towards a statistically significant difference between 2 and 3 consecutive workdays (minimally adjusted model:  $p=0.093$ , fully adjusted model:  $p=0.097$ ).  
‡Statistically significantly different from 0 day off (reference).  
LSM, least squares means.

bodily fatigue on days off from work (suggestive of leisure time). Contrary to the previous study,<sup>31</sup> however, the present study only obtained data on bodily fatigue before and after work and not during explicit leisure time.

### Mental stress

Parallel to bodily fatigue, mental stress was elevated during workdays, while showing signs of recovery manifested by ~0.50 point reduction in the mornings after each consecutive workday (table 4A). This indicates that workdays per se are associated with a heightened state of mental stress, but without accumulating effects. Furthermore, days off from work effectively reduced mental stress. Physical and mental job demands are important determinants of worker well-being,<sup>1</sup> and the present data show that physically demanding working conditions can predict day-to-day changes in mental stress. While the association may not follow an exposure–response pattern, >20% of the workers reported feeling stressed ‘often’ or ‘all the time’ within the past 2 weeks when responding to the baseline questionnaire (table 1). Thus, it is important to consider mental factors, for example, mental stress, when organising work. Notably,

despite reporting high physical job demands,<sup>16</sup> recent prospective cohort studies have shown that warehouse and construction workers in Denmark generally report relatively favourable psychosocial working conditions.<sup>19</sup> This compares with the present observations of larger relative changes in LBP intensity and bodily fatigue compared with mental stress as well as higher absolute values in markers of physical symptoms (cf tables 2–4). These findings may at least in part explain the more detrimental effects of physical versus psychological symptoms observed in the present study. Because the present study population reported relatively low absolute daily mental stress scores (0–10 NRS) and generally appear to score favourably in terms of psychosocial working conditions, they may have recovered faster from mental stress exposure than physical symptoms such as LBP intensity. Opposite trends have been observed for compensation claimants<sup>11</sup> who may experience more mentally demanding working environments.

Unlike most previous reports, our research investigated day-to-day fluctuations of mental stress during workdays and days off. Similarly, a recent study found that day-to-day stress experiences decreased work engagement among office workers in

**Table 4** Associations between number of consecutive workdays and days off from work and change in mental stress after work and the following morning presented in minimally and fully adjusted models

	Minimally adjusted model		Fully adjusted model	
	LSM	LSM differences	LSM	LSM differences
	Estimates	Difference (95% CI)	Estimates	Difference (95% CI)
<b>(A) Workdays</b>				
<b>After the workday</b>				
0–3 workdays				
0	1.19	Reference	1.16	Reference
1	2.17	0.98 (0.77 to 1.78)*	2.13	0.97 (0.77 to 1.17)*
2	2.31	1.12 (0.90 to 1.34)*	2.27	1.12 (0.89 to 1.34)*
3	2.27	1.08 (0.84 to 1.32)*	2.24	1.08 (0.84 to 1.32)*
<b>The following morning</b>				
0–3 workdays				
0	1.19	Reference	1.08	Reference
1	1.74	0.55 (0.34 to 0.75)*	1.63	0.55 (0.34 to 0.75)*
2	1.66	0.47 (0.25 to 0.70)*	1.55	0.47 (0.25 to 0.69)*
3	1.53	0.35 (0.11 to 0.58)*	1.43	0.34 (0.11 to 0.58)*
<b>(B) Days off</b>				
<b>After the workday</b>				
0–2 non-workdays				
0	1.95	Reference	1.76	Reference
1	1.07	–0.88 (–1.05 to –0.71)†	0.88	–0.88 (–1.05 to –0.71)†
2	0.94	–1.01 (–1.21 to –0.81)†	0.75	–1.01 (–1.21 to –0.81)†
<b>The following morning</b>				
0–2 non-workdays				
0	1.51	Reference	1.37	Reference
1	1.18	–0.33 (–0.49 to –0.17)†	1.04	–0.33 (–0.49 to –0.17)†
2	1.37	–0.13 (–0.34 to 0.07)	1.23	–0.14 (–0.35 to 0.07)

(A) represents associations between consecutive workdays (0–3 workdays) and change in stress after work and the following morning, while (B) represents associations between consecutive days off (0–2 days off) and change in stress at the 'after the workday' and 'the following morning' time points.  
Minimally adjusted model: adjusted for age, sex, years of employment, job title, low back pain (LBP) intensity the preceding 4 weeks prior to baseline, chronic LBP and perceived stress during the 2 weeks before baseline.  
Fully adjusted model: minimally adjusted model+smoking, leisure-time physical activity, body mass index (BMI), influence at work, access to work tools, role clarity, guidance, community and cohesion between colleagues, recognition, respectful relationship between leader and employees, and fairness.  
\*Statistically significantly different from 0 workday (reference).  
†Statistically significantly different from 0 day off (reference).  
LSM, least squares means.

academia.<sup>32</sup> Collectively, these findings suggest that mental stress may have detrimental effects on workers' well-being, potentially leading to illness and productivity loss. Because only few previous studies have used the 0–10 NRS to examine day-to-day fluctuations in mental stress, a minimally important difference could not be retrieved for the present study. Nonetheless, the relatively low absolute stress values observed in the present study indicate the presence of low mental stress levels as also indicated by the relatively smaller changes in mental stress compared with the physical symptoms. Further, besides affecting mental health, perceived mental stress is known to increase the risk of MSD (including LBP) and sickness absence measured prospectively.<sup>9,33</sup>

### Practical implications

This study provides day-to-day data that can be used to increase our knowledge about how to organise the working week to reduce physical and mental overload, respectively, and ensure sufficient recovery. Previous findings using day-to-day measurements of neck/shoulder pain intensity, bodily fatigue and mental stress found workers with neck/shoulder pain to be more fatigued and stressed than pain-free workers.<sup>31</sup> Collectively, these observations suggest that it is of vital importance to incorporate both

physical and mental job demands when planning the work while concurrently conducting work environmental initiatives to prevent strained workers.<sup>1</sup>

To reduce LBP intensity, bodily fatigue and mental stress, workplaces could consider organising the daily and weekly job tasks to ensure adequate rest or low-intensity periods between physically demanding job tasks.<sup>34</sup> Furthermore, use of assistive devices may decrease the risk of developing musculoskeletal pain.<sup>35</sup> Lastly, a recent systematic review indicated strength training as a highly effective tool to reduce work-related MSD,<sup>36</sup> while also exerting positive effects on selected psychosocial factors.<sup>37</sup>

### Limitations and strengths

The self-reported design may be a limitation of this study, given that a person's mood, health status, interpretation, etc may bias the response, that is, common-method variance.<sup>38</sup> However, the repeated measures design represents a major methodological strength, eliminating recall bias for both exposure and outcome variables, increases statistical power and enables the investigation of day-to-day changes in physical and mental symptoms during workdays and days off. Out of 383 workers invited to participate in the study, 158 were included in the present study,



with dropouts resulting from missing data in the questionnaire replies during consecutive workdays and days off. Various statistical methods exist to handle missing data, for example, multiple imputation and inverse probability weighting.<sup>39</sup> All models possess strengths and weaknesses (biases), and the present study analysed the collected data using the Proc Mixed procedure, which is somewhat capable in handling data missing at random. Another limitation could be that the distribution of daily working hours on each working day was not considered in the present analysis. To account for this, we performed additional statistical analyses during the review process adjusting for daily working hours. However, effect estimates showed only second digit changes, that is, this did not change the overall results and conclusions of the study. A limitation is the absence of data on specific work tasks and body postures during lifting, where the latter may significantly affect musculoskeletal health.<sup>17 40</sup> While the present study provides data on day-to-day changes in physical and mental symptoms, the long-term effects of warehouse and construction work on musculoskeletal health including LBP remain unknown. Using a non-validated scale for measuring day-to-day mental stress levels may be a limitation, although the 0–10 NRS is commonly used to identify temporal changes and effects of intervention (also daily changes in mental stress<sup>31</sup>), and holds practical value in this study as workers responded to the same scale intervals twice daily for 3 weeks. Additionally, the questions in the questionnaire on mental stress may not entirely have been work related. However, because participants received these questions on the same time point for 21 consecutive days, their attendance to work/off work was assumed to constitute a substantial part of their daily variations in mental and physical symptoms. Lastly, the use of the validated NRS for LBP<sup>22</sup> and fatigue<sup>23 24</sup> strengthens the present study.

## CONCLUSIONS

Consecutive workdays led to progressively increased LBP intensity after work, with sustained elevation the following morning, while recovery from the increased LBP required (at least) 2 days off from work. Bodily fatigue and mental stress increased after one workday and remained elevated, with higher levels persisting the following morning after workdays. Notably, 1 day off was sufficient to recover from bodily fatigue and mental stress. This study provides detailed and practical knowledge into day-to-day fluctuations of LBP, fatigue and stress during consecutive workdays and days off in warehouse and construction workers involved in manual lifting tasks, aiding in the organisation of work schedules to promote rest, prevent health issues and maintain productivity.

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