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Overweight, obesity and work functioning: The role of working-time arrangements

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ABSTRACT

Background: Obesity is associated with productivity loss, but little is known about how obese workers function at work and also the role of working-time arrangements on this association is lacking. Therefore, the aim of this study was to examine the association of overweight and obesity with work functioning (WF), and to determine whether the associations differ between workers with different working-time arrangements.

Methods: A cross-sectional study was conducted within the sampling frame of the 'Shift Your Work' study that examined the effect of irregular working-times in relation to health and functioning at work. We included N = 622 Dutch employees, of which N = 384 (62%) were shift-workers, N = 171 (27%) on-call workers and N = 67 (11%) day-workers. Overweight and obesity were defined as BMI 25–30 and ≥30, respectively. WF was assessed using the Work-Role Functioning Questionnaire.

Results: The prevalences of overweight and obesity were 48% and 10% in all workers, 49% and 11% in shift-workers, 45% and 10% in on-call workers, and 49% and 6% in day workers, respectively. In all workers, obesity was associated with lower WF scores for physical demands (adjusted estimate, aB = −5.5). In shift-workers, obesity was associated with lower WF scores for output and physical demands (aB = −8.8 and −6.8, respectively). In day and on-call workers, overweight and obesity were not associated with WF.

Conclusions: Overweight and obesity are highly prevalent in the working population. Obesity might reduce the executive function performance beyond physical limitations, and limit the ability to accomplish tasks successfully, especially in shift workers.

1. Introduction

Obesity is one of the major public health challenges of the 21st century. The prevalence of obesity has tripled in many countries of the World Health Organization (WHO) European Region since the 1980s (World Health Organization, 2015). Currently, 52% of the European adult population is considered overweight or obese (Muller-Riemenschneider et al., 2008; de Mutsert et al., 2013). In 2011, 48% of the Dutch population was overweight, including 11% obese (de Mutsert et al., 2013). In the Netherlands, the annual costs attributable to obesity amount up to 887 million Euros (Muller-Riemenschneider et al., 2008). These costs include direct health care costs and indirect costs, of which most are related to presenteeism (lost productivity at work) (Muller-Riemenschneider et al., 2008). It is also known that the major occupational health problems such as musculoskeletal disorders, mental disorders and cardiovascular diseases, are directly or indirectly associated with obesity (Pandalai et al., 2013), and thus could negatively affect productivity or functioning at work.

Work functioning (WF) refers to the ability of a person to meet all work demands (i.e. work scheduling, output, physical, mental-interpersonal demands) for a given state of health (Amick and Gimeno, 2008). Given the increasing prevalence of overweight and obesity in the aging working population, overweight and obesity could influence the ability to meet these work

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demands. Previous studies suggested that obesity is associated with impaired physical, psychosocial and cognitive functioning (Pagoto et al., 2006). The association of overweight and obesity with productivity loss and sickness absence is also documented (Neovius et al., 2012, 2009; Striegel et al., 2012; Gates et al., 2008). For instance, Neovius et al. revealed that obesity is associated with almost twice as high productivity losses to society as for normal weight over life time (Neovius et al., 2009), and that obesity is associated with longer episodes of sick leave (Neovius et al., 2012). Gates et al. also examined the impact of obesity on workplace productivity using the Work Limitations Questionnaire (WLQ) (Gates et al., 2008), but did not take working time arrangements into account. In the present study, the Work Role Functioning Questionnaire (WRFQ), a similar instrument as the WLQ, was used to measure work functioning. The WRFQ is a cross-culturally adapted and validated instrument with good psychometric properties (Abma et al., 2013a). More studies are needed regarding the association of overweight and obesity with work functioning (i.e. productivity loss at work for a given state of health).

Furthermore, growing evidence suggests that working time arrangements (i.e. odd or irregular working times) negatively affect productivity at work and health via disruption of normal diurnal biological rhythms, lifestyle changes and social isolation (Scheer et al., 2009; Di Lorenzo et al., 2003). In modern society, working times are no longer fixed and strictly limited to normal diurnal working days as working hours are extended to evening and night hours, and are becoming more and more variable (Costa, 2003). According to an EU survey on working conditions, around 20% of the European working population is involved in some form of shift work (Parent-Thirion et al., 2007). It has been shown that overweight and obesity are more prevalent in shift-workers compared to day workers (Di Lorenzo et al., 2003). It is possible that shift work increases weight gain or exacerbate the effect of obesity on WF through poor sleep quality and short sleep duration, which are the prevailing problems reported by shift workers (Costa, 2010). Increased fatigue is among the negative consequences of reduced sleep length, disturbed patterns of sleep and impaired sleep quality among shift-workers, thereby affecting the ability to meet the work demands (Di Lorenzo et al., 2003; Costa, 2010). Moreover, sleep disturbances have been associated with an imbalance in appetite hormones that increase feelings of hunger and metabolic changes (Scheer et al., 2009).

Hence, the aim of this study was to examine the association of overweight and obesity with WF, and to determine if the associations differ for workers with different working-time arrangements (i.e. shift workers, on-call workers and day workers). We hypothesized that overweight and obesity are associated with poor WF and the associations are stronger in shift workers than in on-call and day workers. The findings could help identify working time arrangements with high-risks regarding WF.

2. Methods

2.1. Study design and procedures

This cross-sectional study was conducted within the sampling frame of the 'Shift Your Work' study, which was established in 2011 to examine the effects of irregular night and shift work on health, work functioning and social life. Questionnaires were sent to N = 1235 workers (N = 730 shift-workers, N = 280 on-call workers and N = 225 day workers). Shift workers were blue-collar workers of four industrial companies in the process and chemical sector in the Netherlands. Job tasks comprised process and quality monitoring, maintenance and logistics. On-call workers were employed by a company taking care of the gas distribution infrastructure in the Netherlands. Day workers were sampled from one of the four shift work companies and presented a mixture of blue-collar (technical assistance) and white-collar workers (office). A total of N = 793 (64%) workers responded. Out of these, 622 (78%) workers with a mean (SD) age of 44.7 (9.1) years had complete data and constituted the final study sample. The prevalences of overweight and obesity were 48% (N = 300) and 10% (N = 63), respectively. There was no significant difference in socio-demographic characteristics, lifestyle factors, health status and working conditions between in- and excluded participants.

With respect to working-time arrangements (WTA), our sample included N = 384 (62%) shift-workers, N = 171 (27%) on-call workers and N = 67 (11%) day workers. Shift-workers were rotating shift-workers, with a 3-shift, 5- shift or 6-shift schedule. Day workers had working times mostly covering 09:00–17:00 h and on-call workers had a normal daytime job, and were once every 4 weeks 1-week on-call. The characteristics of the participants by WTA category are presented in Table 1.

All workers were informed about the design and aim of the study by the human resource departments during recruitment. Web-based and paper versions of the questionnaire were used. Oral and written informed consent were obtained from all workers. Ethical approval for this study was granted by the Medical Ethical Committee of the University Medical Center Groningen, Groningen, the Netherlands.

2.2. Measurements

2.2.1. Overweight/obesity

The Body Mass Index (BMI) was calculated using self-reported body weight (kg) and height (m). Participants were classified into three BMI categories according to the standard international classification: normal weight (BMI < 25 kg/m^2), overweight (BMI 25.0–29.99 kg/m^2), and obese (BMI ≥ 30.0 kg/m^2) (World Health Organization, 2015).

2.2.2. Work functioning (WF)

WF was assessed with the Dutch version Work Role Functioning Questionnaire (WRFQ) (Abma et al., 2013b). The WRFQ measures the perceived difficulties in meeting work demands among workers given their physical health or emotional problems. It has been translated and cross-culturally adapted to the Dutch context with promising psychometric properties (Cronbach's alphas for the subscales between 0.70 and 0.91, and good content validity (Abma et al., 2013b). The WRFQ consists of 27 items in five subscales: work scheduling demands (five items), output demands (seven items), physical demands (six items), mental demands (six items), and social or interpersonal demands (three items). Work scheduling demands (WSD) capture the worker's needs to manage the workday from beginning to end. Physical demands (PD) measure a range of dynamic and static physical loads required in the conduct of work duties. Mental demands (MD) assess the jobs' cognitive requirements, such as concentration and thinking. Social demands (SOD) assess the interaction of people in the workplace and with clients. Output demands (OD) are those activities related to completing work on time, with high quality and to everyone's (including the worker's) satisfaction (Abma et al., 2013b).

All items of the WRFQ have to be answered on a five-point scale from 0 = difficult all the time (100%), 1 = difficult most of the time, 2 = difficult half of the time (50%), 3 = difficult some of the time, 4 = difficult none of the time (0%). Another response option 'Does not apply to my job' has been added to enable workers to answer, even though a particular demand is not part of their job. The total and subscale scores were summed up separately by adding all answers and the answers in the subscale, respectively. The total and

Table 1
Sample characteristics by working-time arrangements.

Characteristics	Total n = 622	Day workers n = 67	On-call workers n = 171	Shift-workers n = 384	Chi^2-test/F-test
Age, n (%)[a]					
<45 years	274 (45.1)	21 (32.8)	91 (54.2)	162 (43.1)	$P < 0.01$
≥45 years	334 (54.9)	43 (67.2)	77 (45.8)	214 (56.9)	
Educational status, n (%)[a]					
Low	81 (13.7)	3 (4.5)	13 (7.7)	65 (18.3)	$P < 0.001$
Middle	443 (74.8)	30 (44.8)	143 (84.6)	270 (75.8)	
High	68 (11.5)	34 (50.7)	13 (7.7)	21 (5.9)	
Smokers, n (%)	143 (23.0)	13 (19.4)	21 (12.3)	109 (28.4)	$P < 0.001$
No/hardly exercise, n (%)	47 (7.6)	3 (4.5)	12 (7.1)	32 (8.3)	NS
High alcohol consumption, n (%)	95 (12.0)	20 (18.3)	26 (12.7)	49 (10.2)	NS
Body weight, n (%)					
Normal weight (BMI < 25 kg/m^2)	259 (41.6)	30 (44.8)	77 (45.0)	152 (39.6)	NS
Overweight (BMI: 25–29.99 kg/m^2)	300 (48.2)	33 (49.3)	77 (45.0)	190 (49.5)	
Obesity (BMI ≥ 30 kg/m^2)	63 (10.1)	4 (6.0)	17 (9.9)	42 (10.9)	
Work family interference, mean (SD)	3.0 (0.5)	3.3 (0.5)	3.1 (0.5)	2.9 (0.4)	$P < 0.001$
Supervisor support, mean (SD)	11.5 (2.2)	11.6 (1.7)	11.4 (2.2)	11.5 (2.3)	NS
Coworker support, mean (SD)	12.1 (1.8)	12.3 (1.8)	12.4 (1.5)	11.9 (1.9)	$P < 0.01$
Mental health, mean (SD)	50.8 (8.9)	52.6 (7.1)	51.3 (8.1)	50.3 (8.9)	NS
Physical health, mean (SD)	50.7 (7.2)	52.5 (5.3)	51.5 (6.0)	49.9 (7.8)	$P < 0.01$
Work functioning, mean (SD)	86.9 (13.7)	90.2 (9.9)	87.1 (13.1)	86.3 (14.5)	NS

NS: not statistically significant.
[a] For 30 (4.8%) and 14 (2.3%) information on educational status and age were not available.

subscale scores were divided by the number of items and then multiplied with 25 to obtain percentages between 0 and 100, with higher scores indicating better work functioning.

2.2.3. Covariates

Age, educational status, lifestyle factors (smoking, alcohol consumption and exercise), job support (supervisor and co-worker support), work family interference (WFI), physical and mental health were included as potential confounders. These factors have been reported to be associated with either overweight or obesity, and WF, or reported as confounders in previous studies without being on the causal pathway except physical and mental health status (Neovius et al., 2012, 2009; Dawson et al., 2007; Neovius et al., 2008). Age was dichotomized as <45 years and ≥45 years. Educational level was categorized into low (lower secondary education or less), middle (higher secondary education) and high (tertiary or further education). Smoking was dichotomized as current smoker and non-smoker. Alcohol consumption was defined according to the National Institute on Alcohol Abuse and Alcoholism guidelines (NIAAA, 2014). Drinking ≥14 glasses and ≥7 glasses of alcohol per week for men and women, respectively, was considered as high alcohol consumption (binge drinking). Physical exercise was measured with the frequency of exercise of at least 30 min per week and was dichotomized as “not or hardly any exercise per week” and “once or more per week”.

Supervisor social support (SS) (range 0–16) and coworker social support (CS) (range 0–16) were measured using the Job Content Questionnaire (Abma et al., 2013a), with higher scores indicating better support. Work family interference was measured with 10 items from the Survey Work-home Interaction Nijmegen (SWING) (Geurts et al., 2007), with a Cronbach's alpha of 0.80. The scale ranges from 0 to 4, with higher scores indicating less work family interference. The physical and mental health status of the workers was assessed with the short-form 12 (SF-12). The physical component summary (PCS) and mental component summary (MCS) subscales were derived from the SF-12 summary scores, with higher scores indicating better physical and mental health status.

2.3. Statistical analysis

First, we described the socio-demographics, lifestyle factors, body weight, health status, work environment characteristics and WF of the workers by working-time arrangements (i.e. day workers, on-call workers and shift-workers). Data were presented as means and standard deviations (SD) for continuous variables and as percentages for categorical variables and differences in proportions were tested by chi^2-tests and differences in means were tested by analyses of variance (ANOVA).

Second, we compared WF total and WF subscale scores of overweight and obese employees with normal weight employees stratified by working-time arrangements. We checked the presence of interaction by comparing the estimates (B) for the total population and the stratum-specific (i.e. WTA) estimates. Third, we examined the association between BMI classes (normal weight, overweight and obesity), which were dummy-coded variables, and WF total and WF subscale scores using multiple linear regression models. Model 1 tested the crude association of overweight and obesity categories with WF total and WF subscale scores compared with the normal weight group. Model 2 repeated these analyses with adjustment for age, educational status, lifestyle factors (smoking, alcohol consumption and exercise), job support (supervisor and co-worker support), and work family interference. Crude (B) and adjusted regression coefficients (aB) with standard error (SE) were presented for all analyses. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 22.0 (SPSS Inc., Chicago, IL, US).

3. Results

3.1. Overweight, obesity and work functioning

The WF total score was significantly lower in obese workers (84.1, SD = 17.2) as compared to overweight (86.9, SD = 13.9) or normal weight workers (87.7, SD = 12.6) (Table 2). WF subscale scores for physical demands were significantly lower in obese workers (82.1, SD = 23.8) as compared to overweight (88.1, SD = 16.2) and normal weight workers (90.0, SD = 13.3). Other WF subscales were not significantly different between overweight, obese and normal weight workers (Table 2). As shown in Table 3, obesity was associated with lower WF subscale scores for output demands (B = −5.0, $p < 0.05$) and physical demands (B = −7.7, $p < 0.05$) as compared to normal weight counter parts. After

Table 2
Work functioning (WF) total and WF subscale scores and overweight and obesity by working time arrangements.

Working-time arrangements	WF total, mean (SD)	WSD, mean (SD)	OD, mean (SD)	PD, mean (SD)	MD, mean (SD)	SOD, mean (SD)
Total population (n = 622)						
Normal weight	87.7 (12.6)	88.0 (15.1)	85.6 (16.1)	**90.0 (13.3)**	85.9 (17.2)	91.2 (13.8)
Overweight	87.0 (13.9)	87.6 (15.5)	84.6 (18.3)	**88.1 (16.2)**	86.0 (16.6)	91.3 (14.5)
Obese	84.1 (17.2)	85.4 (18.8)	80.6 (21.7)	**82.1 (23.8)**	85.6 (16.3)	91.3 (15.6)
Day workers (n = 67)						
Normal weight	89.4 (9.4)	88.9 (10.9)	85.7 (13.6)	96.2 (6.0)	86.4 (13.8)	92.2 (14.0)
Overweight	91.3 (10.8)	92.6 (12.7)	88.5 (12.9)	92.9 (15.8)	90.4 (12.9)	94.7 (11.6)
Obese	87.6 (5.7)	80.0 (24.5)	81.2 (21.1)	95.2 (4.1)	89.6 (9.9)	97.9 (4.2)
On call workers (n = 171)						
Normal weight	87.0 (13.8)	86.7 (17.3)	84.7 (17.4)	90.9 (11.6)	85.0 (18.8)	89.9 (15.4)
Overweight	86.9 (13.6)	88.1 (15.6)	83.9 (20.7)	88.0 (16.8)	86.9 (14.2)	89.5 (15.1)
Obese	88.6 (6.6)	90.0 (8.7)	86.5 (10.3)	88.0 (12.2)	87.5 (10.4)	94.6 (8.3)
Shift-workers (n = 384)						
Normal weight	**87.7 (12.5)**	88.5 (14.7)	**86.1 (15.9)**	**88.4 (14.8)**	86.3 (17.0)	91.7 (12.9)
Overweight	**86.2 (14.3)**	86.5 (15.8)	**84.2 (18.1)**	**87.2 (15.9)**	84.9 (17.9)	91.4 (14.7)
Obese	**81.9 (20.3)**	83.9 (21.1)	**78.1 (24.8)**	**78.6 (27.4)**	84.4 (18.6)	89.3 (18.1)

Note: WSD: Work scheduling demands; OD: output demands; PD: physical demands; MD: mental demands; SOD: social demands; Bold figures reflect statistically significant differences in estimates across body weight categories ($p < 0.05$).

adjustment for age, education, smoking, alcohol consumption, exercise, co-worker and supervisor support and work family interference, the association of obesity with lower WF scores for output demands attenuated and became non-significant, but the association of obesity with physical demands remained significant (aB = −5.5, $p < 0.05$). Overweight was not significantly associated with WF total and WF subscale scores (Table 3).

3.2. Overweight, obesity and work functioning by working-time arrangements

The prevalences of overweight and obesity were 49% (N = 190) and 11% (N = 42) in shift-workers, 45% (N = 77) and 10% (N = 17) in on-call workers, and 49% (N = 33) and 6% (N = 4) in day workers, respectively. The WF total score was significantly lower in overweight (86.2, SD = 14.3) and obese shift-workers (81.9, SD = 20.3) compared with normal-weight shift-workers (87.7), SD = 12.5, $p < 0.05$. WF subscale scores for physical demands were significantly higher in day workers (94.5, SD = 11.9) as compared to on-call workers (89.3, SD = 14.2) and shift-workers (86.7, SD = 17.3), but other WF subscales did not significantly differ between the working time arrangements. As shown in Table 2, the WF subscales scores for output demands and physical demands were significantly lower in obese shift-workers as compared to normal weight shift-workers (78.1 vs. 86.1 and 78.6 vs. 88.4, $p < 0.001$), respectively. As shown in Table 3, in shift-workers obesity was associated with lower WF total scores (B = −5.7, $p < 0.05$), lower WF subscales scores for output demands (B = −7.9, $p < 0.05$) and for physical demands (B = −9.8, $p < 0.05$) as compared to normal weight workers. After adjustment for age, education, smoking, alcohol consumption, exercise, co-worker and supervisor support and work family interference, the association of obesity with lower WF total scores was attenuated and became non-significant, but the association of obesity with lower WF subscale scores for output demands (aB = −6.8, $p < 0.05$) and physical demands (aB = −8.8, $p < 0.05$) remained significant. In day and on-call workers, both overweight and obesity were not associated with WF total and WF subscale scores (Table 3).

4. Discussion

To our best knowledge, this is the first study examining the

Table 3
The association of overweight and obesity with total work functioning (WF) and WF subscale scores by working-time arrangements.

	WF total		WSD		OD		PD		MD		SOD	
	B(SE)	aB(SE)	B(SE)	aB(SE)	B(SE)	aB(SE)	B(SE)	aB(SE)	B(SE)	aB(SE)	B(SE)	aB(SE)
Total population (n = 622)												
Normal weight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Overweight	−0.7 (1.2)	−0.8 (1.1)	−0.4 (1.3)	−0.2 (1.3)	−0.9 (1.5)	−1.4 (1.5)	−1.9 (1.4)	−2.1 (1.3)	0.1 (1.4)	0.2 (1.4)	0.1 (1.2)	−0.2 (1.2)
Obese	−3.6 (1.9)	−1.4 (1.8)	−2.6 (2.2)	−1.0 (2.1)	**−5.0 (2.5)**	−2.8 (2.5)	**−7.7 (2.2)**	**−5.5 (2.1)**	−0.3 (2.4)	2.4 (2.3)	0.1 (2.0)	1.9 (2.0)
Day workers (n = 67)												
Normal weight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Overweight	1.9 (2.5)	2.2 (2.6)	3.6 (3.2)	3.7 (3.6)	2.8 (3.5)	2.6 (3.7)	−3.3 (3.0)	−2.6 (2.8)	4.0 (3.3)	4.2 (3.6)	2.5 (3.1)	3.9 (3.3)
Obese	−1.8 (5.3)	2.9 (5.6)	−8.9 (6.8)	−6.4 (7.8)	−4.5 (7.3)	−0.1 (7.9)	−0.9 (6.4)	3.7 (6.1)	3.2 (7.0)	8.6 (7.7)	5.7 (6.6)	13.9 (6.9)
On call workers (n = 171)												
Normal weight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Overweight	−0.2 (2.1)	0.3 (2.0)	1.4 (2.6)	2.0 (2.6)	−0.7 (2.9)	−0.4 (2.8)	−2.9 (2.3)	−2.6 (2.3)	1.8 (2.6)	2.7 (2.6)	−0.4 (2.4)	−0.2 (2.4)
Obese	1.5 (3.5)	5.7 (3.5)	3.3 (4.3)	7.0 (4.5)	1.8 (4.9)	8.0 (4.9)	−2.9 (3.8)	0.5 (3.9)	2.5 (4.3)	6.5 (4.5)	4.7 (3.9)	6.3 (4.2)
Shift-workers (n = 384)												
Normal weight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Overweight	−1.4 (1.6)	−1.6 (1.5)	−2.0 (1.7)	−1.7 (1.7)	−1.8 (1.9)	−2.1 (1.9)	−1.1 (1.9)	−1.5 (1.8)	−1.4 (1.9)	−1.3 (1.8)	−0.2 (1.6)	−0.8 (1.5)
Obese	**−5.7 (2.5)**	−4.3 (2.3)	−4.5 (2.8)	−3.9 (2.7)	**−7.9 (3.2)**	**−6.8 (3.1)**	**−9.8 (2.9)**	**−8.8 (2.8)**	−1.8 (3.1)	1.0 (2.9)	−2.4 (2.5)	−1.1 (2.4)

WSD: Work scheduling demands; OD: output demands; PD: physical demands; MD: mental demands; SOD: social demands; #: Reference (Ref.): Normal weight (BMI < 25 kg/m^2); B (SE): crude association with a regression coefficient and standard error; aB: adjusted regression coefficient for age, educational status, smoking, alcohol, exercise, co-worker and supervisor support and work-family interference; se: standard error; Bold figures reflect statistically significant differences in estimates across body weight categories ($p < 0.05$).

association between overweight, obesity and WF in workers with different working time arrangements (i.e. shift-workers, on-call workers and day workers). In shift-workers, obesity was associated with lower WF total scores, lower WF subscales scores for output demands and for physical demands as compared to normal weight workers. After adjustment for age, education, smoking, alcohol consumption, exercise, co-worker and supervisor support, and work family interference, the association of obesity with lower WF total scores was attenuated and became non-significant. However, the association of obesity remained significant with lower WF subscale scores for output demands and physical demands. Overweight in all workers and obesity in day and on-call workers were not associated with WF total and WF subscale scores.

Our finding that obesity was associated with the lower WF total scores and lower WF scores for physical demands is in line with earlier studies (Neovius et al., 2009; Striegel et al., 2012; Gates et al., 2008; Mond et al., 2007; Cavuoto and Nussbaum, 2014). In particular, Gates et al. showed that job limitations most affected by obesity were those with time and physical demands (Gates et al., 2008). In the adjusted model, the association between obesity and lower WF scores was explained by lifestyle factors and the ability of the employee to balance their work and family roles. Jagielski et al. also showed that an increase of 1 BMI unit was associated with a decrease of 1.93 in physical well-being, which might affect physical demanding tasks (Jagielski et al., 2014). This suggests that the association between obesity and WF for physical demands might be through physical impairment. Earlier studies showed a significant reduction of the number of body joint motions (e.g. shoulder, knee joints among others) and postures (Park et al., 2010 Jan; Park et al., 2009 Sep), and of postural sway and control (Singh et al., 2009 Aug) in obese workers. This may cause physical incapability to perform work and daily activities. For instance, obese individuals may be more prone to balance loss and falling than non-obese individuals during a prolonged standing task (Koepp et al., 2014 Dec 22; Mehta and Cavuoto, 2015; Peduzzi de Castro et al., 2014 Jul). Although Strigel et al. did not consider specific work demands in relation to overweight and obesity, the authors reported the association between obesity and work impairment and they assessed WF by the Work Productivity Activity Impairment questionnaire (Striegel et al., 2012). In contrast, Robroek et al. reported no association between obesity and productivity loss at work (Robroek et al., 2011). Possible explanations for the discrepancy are the differences in study population, instruments used to assess WF, and the type of confounding variables. In Robroek et al.'s study, productivity loss at work was assessed by a single item of productivity loss of the quantity scale of the Quantity and Quality (QQ) method, while the present study used the 27-item WRFQ covering the five different domains of work demands.

The finding that overweight and obesity were not associated with WF total scores and WF subscale scores for mental demands and social or inter-personal demands is consistent with earlier studies (Gates et al., 2008; Mond et al., 2007; Robroek et al., 2011; Tunceli et al., 2006). All these studies showed that overweight and obesity may be related to poor WF regarding for specific work demands (i.e. physical demands), but not regarding social and inter-personal demands in working population. Working in industrial companies requires workers to be able to adapt to the work environment and to engage in various physical movements, including bending, stretching, squatting, pushing and walking. Obese people often experience difficulties in these movements because of their body size and weight. It is also well known that obesity is associated with the development of musculoskeletal disorders, osteoarthritis, rheumatoid arthritis and carpal tunnel syndrome (Schulte et al., 2007; Viester et al., 2013 Aug 12). Workers with these health conditions are more likely to have physiological and respiratory strains during performance of hard physical work, have accidents during work, and consequently a decrease in productivity.

The finding that obesity is associated with lower WF subscale scores for physical and output demands in shift-workers is in line with Caruso's finding, which showed that the association between obesity and lower productivity was stronger in shift workers than day workers (Caruso, 2014). The occupational hazard of shift work has been documented in a multitude of studies (Di Lorenzo et al., 2003; Costa, 2003, 2010). Two systematic reviews have shown that shift working is associated with poor health and well-being, and increases the risk of weight gain in employees (Antunes et al., 2010; Amani and Gill, 2013). A review by Folkard et al. showed that this negative influence of shift work systems on productivity is underlined by psychosocial work conditions and physical health (Folkard and Tucker, 2003). From their review, they conclude that a clear understanding of these underlining factors can help to cope properly, and to minimize the possible risks associated with shift work.

A possible explanation for the association of obesity with lower WF for physical and output demands in shift-workers is that obesity and shift work interact through sleep–wake cycles, body temperature, energy metabolism and hormone secretion, which are regulated by the circadian clock (Antunes et al., 2010). For instance, sleep disturbance promotes an imbalance in appetite hormones and increase feelings of hunger and metabolic changes (Costa, 2003). Another possible explanation is that obese workers might not be able to meet a range of dynamic and static physical loads required in the conduct of work duties (Amick and Gimeno, 2008; Di Lorenzo et al., 2003; Costa, 2003). High physical work demands may increase their risk of musculoskeletal pain and may decrease their work ability. This may lead to a higher relative workload and increased rate of perceived physical exertion during manual work. The extra fat mass in the obese body also increases biomechanical and physiological stresses during physically demanding activities (Singh et al., 2014 Sep 23). Shift work was associated with deleterious lifestyle changes, a poorer lipid profile, lower cognitive abilities (Ansiau et al., 2008; Rouch et al., 2005), and reduced professional performance and judgment (Bekkers et al., 2015; Pikovsky et al., 2013), thereby possibly exacerbating the effect of obesity on lower WF. The combination of poor lifestyles, high perceived physical exertion and musculoskeletal pain may increase the risk of decreased work ability and performance on the job for physical and output demands in obese shift workers.

In addition, it has been repeatedly shown that overweight and obese people suffer from a higher incidence of chronic diseases, including musculoskeletal disorders and mental disorders (Muller-Riemenschneider et al., 2008). Furthermore, an elevated body mass index is characterized by a reduced tolerance to effort and lack of satisfaction (Pagoto et al., 2006; Singh et al., 2009 Aug), a reduced executive function performance (Gunstad et al., 2007), a reduced muscle strength normalized per body weight and lower tolerance to prolonged postures and sleep disturbances (Pandalai et al., 2013; Di Lorenzo et al., 2003; Costa, 2010; Singh et al., 2009 Aug; Cavuoto and Nussbaum, 2013), which could explain the underlying mechanisms between obesity and lower WF in the working population, especially in shift-workers.

4.1. Strengths and limitations

The strength of our study is that we used work functioning data of workers with different working time arrangements; i.e., shift-workers, on-call workers and day workers. We used the WRFQ to measure specific work demands. To our knowledge, this study is

the first study to assess overweight and obesity in relation to WF in workers with different working time arrangements using the validated WRFQ.

The main limitation of our study is the cross-sectional design. Thus, data must be interpreted with caution and no causality or direction of associations between obesity and WF can be inferred. Furthermore, our sample is relatively small and comprised mostly males and shift-workers. In particular, the obese day worker group comprised a relatively small number of respondents. Although findings should be interpreted with caution, the prevalence of obesity in day workers (6%) is comparable with previous findings among Dutch workers (Proper and Hildebrandt, 2010). Nevertheless, the findings should be confirmed in prospective studies with larger samples. Future studies should also assess whether the differences in working-time arrangements as observed in this study reflect basic differences or were due to sleep patterns and other lifestyle changes that were not considered. Finally, as many researchers have been criticizing the BMI for its inadequate reflection of body composition, using BMI to define overweight and obesity might be a limitation, but it has been found that BMI is a valid anthropometric indicator of body weight and the best predictor of weight-related risks to work ability among Finnish employees (Korpela et al., 2013).

4.2. Implications

Our findings may have implications for ergonomics and public health interventions. Irregular working time arrangements are becoming more and more common and obesity is a growing epidemic in working population. Our findings demonstrated a stronger association of obesity with lower WF for physical and output demands in shift-workers. Therefore, workplace health promoting activities are warranted such as providing information, activities, and social support, and organizational structures that can help to guide certain behaviors and discourage others. For example, workplaces can engage in the promotion of physical activity (i.e. walking stairs and standing desk) and healthy diet (e.g. Offer healthier food choices in vending machines, canteens or cafeterias) at work, inform shift workers about proper sleep hygiene in such a way that the shift schedules minimize circadian disruption and provide sufficient time to recover. Organizational interventions may be a good strategy to reduce the burden of obesity in shift workers. Previous studies suggested that workplace health promotion can improve workers health, employee satisfaction, organizational atmosphere and total organizational costs (Goetzel et al., 2005; Smith et al., 2015).

4.3. Conclusions

In conclusion, the present study indicates that overweight and obesity are prevalent in the working population, mainly in shift workers. Associations between obesity and WF total and WF for physical and output demands were found in shift-workers, but not in on-call and day workers. There was no association between overweight and WF total and WF subscale scores. Hence, it seems likely that obesity may lead to decreases in WF scores in workers especially in shift-workers. Longitudinal studies are needed to examine the temporal relationship between obesity and subsequent decrease in WF scores, and the role of working-time arrangements.

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Conflicts of interest

The authors declared no conflict of interest.

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