Public Health Nutrition: 17(11), 2619–2623 doi:10.1017/S1368980013002838

Sleep deprivation and obesity in shift workers in southern Brazil

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Submitted 23 April 2013: Final revision received 7 September 2013: Accepted 10 September 2013: First published online 29 October 2013

Abstract

Objective: The objective of our study was to explore the association between sleep deprivation and obesity among shift workers.
Design: A cross-sectional study was conducted. Obesity was defined as BMI $\geq 30\,kg/m^2$. Time of sleep was categorized as: >5 h of continuous sleep/d; ≤ 5 h of continuous sleep/d with some additional rest (sleep deprivation level I); and ≤ 5 h of continuous sleep/d without any additional rest (sleep deprivation level II). Sociodemographic, parental and behavioural variables were evaluated by means of a standardized pre-tested questionnaire. Potential confounding factors were controlled for in the multivariable model.
Setting: A poultry-processing plant in southern Brazil.
Subjects: Nine hundred and five shift workers (63 % female).
Results: Obesity was more prevalent in the participants who were female, aged 40 years and older, who had less schooling and reported excess weight in both parents. Sleep deprivation levels I and II were associated with increased income, number of meals consumed throughout the day and nightshift work. All of the workers who exhibited a degree of sleep deprivation worked the night shift. After controlling for potential confounding factors, the prevalence ratios of obesity were 1·4 (95 % CI 0·8, 2·2) and 4·4 (95 % CI 2·4, 8·0) in the workers with sleep deprivation levels I and II, respectively, compared with the reference group.
Conclusions: These results show a strong association between sleep deprivation and obesity in shift workers and that sleep deprivation may be a direct consequence of working at night.

Keywords
Obesity
Sleep deprivation
Shift work

The number of people who are obese is increasing worldwide including in Brazil[1]. Recent data from the Family Budget Survey, carried out between 2008 and 2009, showed that in Brazil obesity affects approximately 14 % of adults over the age of 20 years[2]. Obesity is linked to many adverse health outcomes, including diabetes, CVD, cancer and overall mortality[3–6]. Traditionally, causes of obesity have been linked to the imbalance between energy intake and physical activity[7]. However, modern life has led to other changes in human behaviour, such as shift work and sleep deprivation.

Shift work is becoming increasingly prevalent worldwide. There is no official estimate of the number of shift workers in Brazil. However, according to the results of a survey conducted in 2005, more than 17 % of the working population in the European Union are shift workers, with a significant variation among countries (from 6·4 % to 30·0 %)[8]. Many health impairments associated with shift work have been reported, but the most prevalent problem for the shift worker is the quantity and quality of sleep[9–11]. Moreover, a number of studies have associated short sleep duration with higher BMI in adults[12,13].

Despite the rapid growth of the labour force employed in large companies that function 24 h/d in South American countries, until now few studies have investigated the consequences of sleep deprivation on obesity in this population[10]. Thus, the objective of our study was to examine the association between sleep deprivation and obesity. The study was conducted among the employees of a poultry-processing plant in southern Brazil that functions 24 h/d.

Methods

The study was conducted among the employees of a large poultry-processing plant located in southern Brazil that functions 24 h/d. The employees worked on the plant's

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production line in three main sectors: evisceration, cutting room and thermoprocessing. The cross-sectional study included workers aged 18 to 50 years who had been working fixed shifts for more than 6 months on the plant production line. Pregnant women and employees who had not worked for more than 10 d were excluded from the sample.

The company employed 2645 workers, men and women, who lived in the headquartered municipality or in six other neighbouring municipalities. For logistical reasons, such as distance and urban area, all of the employees living in the headquartered municipality (*n* 710) and in the two closest municipalities (*n* 195) were included, summing to a sample size of 905 workers. An *a posteriori* calculation of power was performed: considering an 80 % power and a significance level of 5 %, this sample had the power to show differences of 50 % in the obesity prevalence rate between sleep deprivation categories.

Obesity was assessed by BMI, which was calculated by dividing the participants' weight (in kilograms) by the square of their height (in metres). Weight measurements (in kilograms) were made using a Plataform Toledo scale, digital model 2096PP (São Paulo, Brazil) which can accurately measure up to 200 kg, and height measurements (in centimetres) were obtained using a Seca Bodimeter 208 (Hamburg, Germany) portable stadiometer with scale increments of 1 mm. The BMI cut-off point for obesity was $\geq 30\,kg/m^2$.

Sociodemographic, parental overweight, behavioural and sleep characteristics were evaluated using a standardized pre-tested questionnaire. All interviews were conducted in the workers' homes between January and May 2010. The sociodemographic variables were age (continuous variable categorized into quintiles), skin colour (self-reported by the interviewees and categorized as 'white' or 'other'), marital status (classified as 'having a partner' or 'not having a partner'), years of education (categorized as '1–4 years of elementary school', '5–8 years of elementary school', 'did not complete high school' or 'completed high school and higher') and total family income (continuous data categorized into quartiles). The parental overweight status as reported by the interviewee was categorized as obesity in 'neither parent', in 'one parent' or in 'both parents'. The behavioural variables were: leisure physical activity ('active' individuals doing physical activity for ≥150 min/week and 'inactive' individuals doing <150 min/week)[14] and the number of meals per day (one or two meals, three meals, four or more meals). Sleep deprivation was measured by hours of sleep and categorized as >5 h of continuous sleep/d, ≤5 h of continuous sleep/d with some additional rest (sleep deprivation level I) and ≤5 h of continuous sleep/d without any additional rest (sleep deprivation level II). The work schedule was provided by the company and confirmed by the workers through a questionnaire. All participants were permanent shift workers. Those who worked more than 90 % of their hours in the evening or at night were considered to be exposed (i.e. those who started their shift after 17.00 hours). Dayshift workers who started their working hours between 06.00 and 14.15 hours were considered to be non-exposed. Also collected was the period of time (in months) that the employee had worked in the current work shift.

Data were entered into Epidata software with double data entry. Data analysis was performed using the statistical software package STATA version 11·0. Estimates for crude and adjusted prevalence ratios with 95 % confidence intervals were calculated by modified Poisson regression with robust variance. Model 1 was unadjusted. Model 2 was adjusted for demographic and socio-economic variables. Model 3 was adjusted for model 2 and parental overweight status. Model 4 was adjusted for models 2 and 3 and behavioural variables (physical activity, number of meals per day, work shift and period in the current shift). Variables were retained in models as potential confounding factors if they had a P value of <0·20.

This project was approved by the Research Ethics Committee of the University of Vale do Rio dos Sinos, RS, Brazil, as recommended by resolution 196/96 which relates to human research.

Results

The mean age of the participants was 31 (SD 8·7) years and 63 % were female. A total of 10·8 % of the workers were obese (95 % CI 8·7, 12·8 %). The prevalence of sleep deprivation levels I and II was 18·0 % (95 % CI 16·0, 20·3 %) and 1·8 % (95 % CI 1·1, 2·5 %), respectively.

Table 1 shows the prevalence of obesity and sleep deprivation levels I and II in the workers according to sociodemographic characteristics, parental excess weight, behavioural traits and work shift. Obesity was more prevalent in the participants who were female, aged 40 years and older, had less schooling and reported excess weight in both parents. Sleep deprivation levels I and II were associated with increased income, number of meals consumed throughout the day and nightshift work. All of the workers who exhibited a degree of sleep deprivation worked the night shift.

Table 2 describes the associations between the different levels of sleep deprivation and obesity. The workers who reported a degree of sleep deprivation had a higher prevalence of obesity, which is an independent effect that increased after adjusting for possible confounding factors. After controlling for sociodemographic characteristics, parental excess weight, behavioural traits and work shift, the prevalence ratios were 1·4 (95 % CI 0·8, 2·2) and 4·4 (95 % CI 2·4, 8·0) in the workers with sleep deprivation levels I and II, respectively, compared with the reference group (>5 h of continuous sleep/d).

Table 1 Prevalence and 95 % confidence interval of obesity* and sleep deprivation level I and II† according to sociodemographic, hereditary and behavioural characteristics among shift workers in southern Brazil, January–May 2010

	Obesity			Sleep deprivation level I		Sleep deprivation level II		
Variable (*n*)	%	95 % CI	*P*‡	%	95 % CI	%	95 % CI	*P*‡
Sex			0·016					0·342
Male (304)	7·2	4·3, 10·1		16·4	14·1, 21·6	1·0	0·1, 3·4	
Female (601)	12·4	9·8, 15·1		18·8	15·7, 21·3	2·0	1·0, 3·2	
Age			0·001					0·585
18–22 years (164)	5·4	1·9, 9·0		16·3	12·0, 21·5	2·4	0·1, 5·1	
23–26 years (189)	7·9	4·0, 11·8		20·1	15·4, 25·6	1·1	0·0, 3·4	
27–31 years (158)	12·6	7·4, 17·8		16·9	12·2, 22·6	1·8	0·1, 4·6	
32–39 years (209)	11·0	6·7, 15·2		22·0	17·0, 27·6	1·2	0·2, 3·5	
40–50 years (185)	16·2	10·8, 21·6		10·7	7·1, 15·4	2·6	0·1, 0·5	
Marital status			0·053					0·085
Having a partner (273)	7·7	4·5, 10·8		13·9	10·0, 18·0	2·2	0·1, 4·7	
Not having a partner (632)	12·0	9·4, 14·5		19·7	16·7, 23·1	1·4	0·1, 2·6	
Skin colour			0·751					0·494
White (773)	10·6	0·8, 12·7		17·6	15·0, 20·4	3·5	2·3, 5·0	
Other (132)	11·5	5·9, 17·1		20·8	14·1, 28·7	0·1	0·0, 4·2	
Schooling			0·007					0·596
1–4 years of elementary school (116)	15·6	10·0, 21·2		18·7	13·0, 25·4	1·8	0·1, 5·2	
5–8 years of elementary school (228)	12·3	8·0, 16·5		15·3	10·9, 20·7	1·3	0·0, 3·8	
Did not complete high school (72)	6·9	0·9, 13·0		12·5	5·8, 22·4	2·7	0·3, 9·6	
Completed high school and higher (435)	8·4	5·8, 11·0		20·1	16·4, 24·1	1·6	0·1, 3·2	
Income quartile			0·323					0·042
I (208)	8·2	4·4, 11·9		13·9	9·5, 19·4	1·0	0·0, 3·4	
II (223)	9·8	5·9, 13·8		18·8	14·0, 24·6	1·8	0·1, 4·5	
III (235)	14·0	9·5, 18·5		18·3	13·5, 23·8	1·3	0·0, 3·6	
IV (228)	10·5	6·5, 14·5		21·0	16·0, 27·0	2·2	0·1, 5·0	
Parental overweight status			<0·001					0·793
Neither parent (669)	7·0	5·1, 8·9		18·1	15·2, 21·2	1·5	0·1, 2·7	
One parent (193)	19·7	14·2, 25·3		16·1	11·2, 22·0	2·1	0·1, 5·2	
Both parents (39)	28·2	13·4, 43·0		23·1	11·1, 39·3	2·6	0·0, 13·5	
Physical activity			0·951					0·447
Inactive (581)	10·6	8·1, 13·2		16·9	13·9, 20·1	1·5	0·1, 2·9	
Active (324)	10·8	7·4, 14·2		20·1	15·8, 24·8	1·8	0·1, 4·0	
Work shift			0·526					<0·001
Day (325)	9·8	6·6, 13·1		0	–	0	–	
Night (580)	11·2	8·6, 13·8		28·1	24·4, 32·0	2·6	1·4, 4·2	
Number of meals per day			0·291					<0·001
One or two (154)	15·6	10·0, 212		13·6	8·6, 20·1	2·6	0·1, 6·5	
Three (459)	12·3	8·0, 16·5		14·1	11·1, 17·7	1·3	0·1, 2·8	
Four or more (292)	8·2	5·8, 10·6		26·4	21·4, 31·9	1·7	0·0, 3·9	

*BMI ≥30 kg/m^2.
†Sleep deprivation level I, ≤5 h of continuous sleep/d with some additional rest; sleep deprivation level II, ≤5 h of continuous sleep/d without any additional rest.
‡*P* value from χ^2 test.

Table 2 Crude and adjusted prevalence ratios of obesity (BMI ≥ 30 kg/m^2) on sleep deprivation adjusted for sociodemographic and behavioural characteristics among shift workers in southern Brazil, January–May 2010

	Model 1			Model 2			Model 3			Model 4		
Sleep	PR	95 % CI	*P**	PR	95 % CI	*P**	PR	95 % CI	*P**	PR	95 % CI	*P**
Reference category	1·0	–	0·002	1·0	–	0·003	1·0	–	0·002	1·0	–	0·003
Sleep deprivation level I	1·2	0·8, 2·0		1·3	0·7, 2·0		1·3	0·8, 2·0		1·4	0·8, 2·2	
Sleep deprivation level II	4·8	2·7, 8·7		4·8	2·2, 10·0		4·6	2·5, 8·3		4·4	2·4, 8·0	

PR, prevalence ratio; Model 1, crude analyses; Model 2, adjusted for demographic and socio-economic variables; Model 3, adjusted for model 2 and parents' overweight; Model 4, adjusted for models 2 and 3 and behavioural variables (physical activity, number of meals per day, work shift and period in the current shift); sleep deprivation level I, ≤5 h of continuous sleep/d with some additional rest; sleep deprivation level II, ≤5 h of continuous sleep/d without any additional rest.
**P* value from Wald test.

Discussion

The main results show a positive association between sleep deprivation and obesity in workers after controlling for possible confounding factors. The workers with sleep deprivation level II (≤5 h of continuous sleep/d without additional rest) were more likely to be obese compared with the reference group (>5 h of continuous sleep/d).

Several studies conducted in different populations have reported similar findings. In a systematic review of observational studies, Patel and Hu concluded that there is an independent association between shortened sleep duration and weight gain[12]. Gangwisch *et al.* analysed longitudinal data from the National Health and Nutrition Examination Survey (NHANES I) and found that the individuals who reported sleeping for less than 6 h per night had a higher BMI than individuals who slept for more than 6 h per night[13]. Patel *et al.* followed 68 183 women for 16 years as a part of the Nurses' Health Study and found a dose–response association between sleep duration and weight gain, with the greatest average weight gain being observed in the women who slept for 5 h or less[15]. In Brazil, Moreno *et al.* described a greater prevalence of obesity in truck drivers who slept for less than 8 h per night[10].

The mechanisms that link sleep deprivation to weight gain are still not clear. Acute exposure to sleep deprivation in man is associated with thermoregulatory effects and is related to a reduction in total energy expenditure[16,17]. Individuals with sleep deprivation may increase their total energy intake due to the impact of sleep deprivation on the peripheral regulators of satiety. Several studies have associated sleep deprivation with reduced leptin and increased ghrelin levels and a consequent increase in appetite and weight gain[18,19].

Regarding the factors associated with sleep deprivation in the present study, the only behavioural trait associated was the number of meals consumed throughout the day. Intake of four or more meals was associated with sleep deprivation level I, while intake of two or fewer meals was associated with sleep deprivation level II. Because the present study was cross-sectional, it is not possible to establish whether sleep deprivation influenced the number of meals consumed by the workers during the day or whether nutritional aspects led to sleep issues. However, reduced sleep duration is known to have consequences on individuals' social routines and lifestyles, particularly regarding dietary habits and level of physical activity. Although the influence of shortened sleep duration on dietary habits has not been well described in the literature, an increase in total energy consumption and a tendency to skip meals appear to be involved[15,20–22].

Sleep deprivation is one of the main consequences of shift work[23]. In the present study, all of the workers who exhibited a level of sleep deprivation worked the night shift, which is characterized by being awake during periods that are physiologically allocated for sleep. Thus, it is difficult to distinguish between the role of sleep deprivation and the role of nightshift work on weight gain in this population because the observed weight gain could be due to a shortened sleep duration and disruption of the circadian rhythm. A recent systematic review investigated the effects of shift work on weight gain and found strong evidence indicating that shift work is an independent risk factor for weight gain. However, none of the articles included in that review investigated duration of sleep in the participants[24]. Canuto *et al.* suggested evaluating sleep deprivation as a possible factor mediating the association between shift work and metabolic disorders[25].

The workers who reported greater income level had increased levels of sleep deprivation. One hypothesis is that these individuals work double shifts to increase their income. In addition to the nightshift job, they have another job during the day that prevents longer sleep duration. Our study measured the family income but did not investigate the workers' specific earnings.

These results must be interpreted within the context of several limitations. Because it was a cross-sectional study, exposure and disease were measured concurrently, and it is difficult to assess whether sleep deprivation led to obesity or obesity induced the development of sleep disorders. The study was conducted with fixed shift workers and cannot be extrapolated to rotating shift workers. The classification of different levels of sleep deprivation may be considered arbitrary because the definition of normal sleep duration varies from 6 to 9 h/d. However, metabolic disorders and weight gain have been observed in individuals who sleep for less than 6 h per night[15,18].

Conclusion

The present results show a strong association between sleep deprivation and obesity in shift workers. The study contributes to understanding the risk factors for obesity and sleep deprivation in shift workers. Future studies with different methodological designs and populations should be conducted to understand better the associations between shift work, sleep deprivation and excessive weight gain.

Acknowledgements

Sources of funding: This study was supported by the National Council of Technological and Scientific Development (CNPq; grant numbers 477069/2009-6 and 478366/2011-6). R.C. received a scholarship from the Brazilian Federal Agency for Support and Evaluation of Graduated Education (CAPES). M.T.A.O. and M.P.P. received research productivity grants from CNPq (grant numbers 304793/2010-8 and 303424/2011-7). The funders had no role in the study design, data collection and analysis, decision to publish and preparation or approval of the manuscript. *Conflicts of interest:* None. *Authors' contributions:* All authors participated in the design, analysis and writing of the manuscript.

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