Review Article

Shiftworking, nutrition and obesity: implications for workforce health- a systematic review

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Background: Shiftworking has long been unrecognised as an occupational health hazard up until now. Methods: Electronic databases were searched using OVID host as the main search engine for Medline, PUBMED and CINHAL during the years 1990-December 2010. Combinations of the keywords yielded 35 full papers and abstracts, of which 16 articles were relevant. One paper was not in English, leaving 15 included in this review after final reconsideration. Studies were categorised into two main titles: studies assessing the association between shift working and obesity and/or BMI (n=8) and studies assessing the association between shift working and nutritional/dietary patterns (n=7). Type of study was also considered as a part of the search strategy. Results: In total, one interventional, nine cross-sectional and five cohort studies were retrieved. Seven cross-sectional studies and one cohort study showed a higher BMI/obesity prevalence in shiftworks. Interventional, one cross-sectional and three cohort studies showed higher frequency of meal intake or poor nutrition quality/habits in the shift workers compared with the day-shift workers. Another cross-sectional study showed no difference between workers. Conclusion: In terms of obesity or high BMI, majority of cross-sectional studies indicate that shiftwork increases weight gain and the prevalence of obesity. On the other hand, half of cohort studies show higher frequency of meal intake and/or poor nutrition quality in the shift workers. Generally, it is indicated that shift working negatively impacts on health and nutritional status of workforces.

Key Words: shift working, nutrition, obesity, workforce, systematic review

INTRODUCTION

In recent years, economic and industrial innovation has resulted in far fewer workers in primary industries (eg, agriculture, fishing, mining, or forestry); more automation and labour-saving devices in production industries; and large increases in the proportion of people engaged in sedentary industries.

Workplaces are a sedentary setting for many workers and also a place where access to energy-dense food and beverages is common. Epidemiological studies of characteristics of working conditions and workers overweight or obesity have shown associations between greater BMI and long work hours, shift work, and job stress.[1,2]

Schulte *et al* have described the association between excess body weight and risk for a range of occupational conditions, including injury, asthma, musculoskeletal disorders, immune response, neurotoxicity, stress, cardiovascular disease, and cancer.[2]

In the workplace, obesity is an important driver of costs associated with absenteeism, sick leave, disability, injuries, and healthcare claims.[3-5]

In the workplaces, strategies employed to promote healthy eating to date have largely focused on individual responsibility (education and behaviour change). However, some programs have implemented changes to worksite environments in order to make healthy choices easier but these have largely focused on changing the physical environment, ie food availability, and have mostly failed to tackle the economic, political, and socio-cultural aspects of the worksite.[6]

Regarding nutritional strategies for shift workers, there are some general advices available in non-scientific commercial websites. However, no clear recommendations have been published in this area so far and it seems that in addition to general guidelines, we need more practical and specialized recommendations to meet the workers' nutritional requirements in different settings with various conditions such as work shifts.

Benefits of workplace health/nutrition promotion programs

Employers are keenly interested in programs and policies that improve workers health and ultimately reduce healthcare costs.[7]

The consequences of poor diet and excess body weight impact directly on employers, with obesity being one of

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the most common and costly health problems encountered at work, and many others (back pain, stress, coronary heart disease and diabetes) are causally linked to poor diet and obesity.[6] Obese people also suffer more sickness and absences from work,[8] with around 16 million lost working days attributable to obesity-related illness in the UK in 2002.[9]

Achieving a healthy workforce should therefore not only result in improved health for individuals, but also bring benefits to employers and society. In addition to reducing absenteeism, worksite initiatives to promote health and well-being lead to economic benefits for businesses.[10] Since individuals spend up to 60% of their waking hours in their place of work, worksite interventions have significant potential to improve dietary habits and promote weight loss. In addition, effective interventions may lead to secondary improvements in lifestyles of employees and their families outside of the worksite.[6]

Nutrition and shift working

Shift work is extremely frequent in several services and industries, in order to meet the needs for flexibility of the workforce, necessary to optimize the productivity and the business competitiveness in developed countries, and the proportion of shift workers is now estimated to represent more than 20% of the entire working population.[12,13]

Nowadays, all societies are moving toward a pattern of working twenty-four hours a day. Increasingly other services such as restaurants, petrol stations, and grocery/ convenience stores are open twenty-four hours in order to accommodate night workers.[14]

Shift work is associated with several health problems, possibly due to an impairment of biological rhythms. In particular, an increased risk of coronary heart disease (CHD) has been reported in several studies performed in shift workers.[15,16] with a direct association between relative risk (RR) for CHD and time of exposure to shift work.[17]

As people work irregular hours, their daily routine is interrupted. Regular eating and exercise habits are difficult to maintain.[14] Consequently, shift workers have a higher prevalence of being overweight.[18,19] In addition, shift workers also have more adverse life-style behaviours, such as higher tendency to smoke [20] and drink alcohol.[21] These daily habits (diet, exercise, smoking and alcohol consumption) and their immediate consequences (eg obesity) are the fundamental causes of many chronic diseases.[22]

An unhealthy lifestyle often leads to being overweight and contributes to circulatory diseases, diabetes mellitus and various forms of cancer.[23] Lack of exercise is closely associated with food related ill health.[24]

We have been unable to identify an existing comprehensive systematic review paper published in the area of nutrition and shift-working. We specially looked at the studies mainly conducted in the field of nutritional assessment/intervention at the work sites. Because of the nature and outcomes of studies and the way the data has been presented, no meta-analysis could be carried out here.

METHODS

Search strategy

Electronic databases were searched using OVID host as the main search engine for Medline, PUBMED and CINHAL during the years 1990 to May 2011. The key searching terms included: shift-work, shiftwork, shift work, nutrition, diet, obesity, BMI, lifestyle, food, worksite, workplace with a combination of AND/OR between terms. These combinations yielded 35 full papers and abstracts, of which 17 articles were relevant. One paper was not in English (just abstract in English), leaving 16 papers; one interventional, nine cross-sectional and five cohort studies that were included in this review after final reconsideration (totally 15 studies because two papers had been published from one cohort study).

The selection process was done based on:

- Clarity of study design/method (ie observational or analytical);
- The possibility of drawing sufficient details in the case of abstracts;
- The subjects of study who were shift-workers; and
- Outcomes (such as nutritional status, overweight/ obesity, and anthropometric indices like BMI)
- Published in English with full text available for review.

RESULTS

In this review, we have examined fifteen studies that met all inclusion criteria. Eight studies[12,18,21,25-29] assessed the association between shift working and obesity-overweight/anthropometric indices. The other seven studies[14,19-20,30-34] analysed the association between shift working and nutritional/dietary patterns. As mentioned earlier, two papers were published from the same study.[32,33]

Studies assessing association between shift working and obesity and/or BMI

Cross-sectional studies:

Ghiasvand *et al*,[25] evaluated the association between shift work and biochemical variables and blood pressure, in a total of 424 Iranian rail road workers (21-64 years). Subjects included 158 (37.3%) shift workers and 266 (62.7%) day workers. Shift workers were defined as work at times other than normal daylight hours of approximately 7:00 AM to 6:00 PM or work during the weekends. High levels of total cholesterol (>200 mg/dL) and LDL-cholesterol (>130 mg/dL) were significantly more preva-

Table 1. Possible benefits of workplace health/nutrition promotion programs that target physical activity, diet or both (WHO 2008)

Intervention	Physical activity	Diet	Physical activity and diet
Benefits	- Increased physical activity Reduced relative body fat percentage - Decreased musculoskeletal disorders - Improved cardiorespiratory fitness	- Increased fruit and vegetable intake - Decreased unhealthy dietary fat intake - Reduction in weight and BMI	- Promote lifestyle behaviours - Improved risk factors for non-communicable diseases - Facilitate organizational level change

lent in nearly all groups of shift workers irrespective of their ages. No differences were seen in obesity prevalence (BMI ≥30), the serum levels of triglyceride, HDL-C, fast ing blood glucose and blood pressure levels between shift workers and day workers. Adjusted odds ratio (OR) (95% confidence interval (CI)) for the effect of shift working on high serum total cholesterol and LDL-C level were 2.11 (1.33-3.36) and 1.76 (1.09-2.83), respectively. The authors concluded that shift working is a risk factor for lipid profile disturbances.

In Malaysia, Chee *et al*[18] conducted a cross-sectional survey to examine the socio-demographic and lifestyle factors that are associated with being overweight among 1612 females working in 10 large electronics assembly factories. More than 78% of the subjects were Malay and about 71 percent of them were below 35 years old. More than half of the women (57.6%) worked three shifts, rotating every seven to ten days. Data were obtained by self-administered questionnaires and anthropometric measurements. The results revealed that working in rotating shifts including nights was significantly associated with being overweight (as defined by BMI) after adjusting for age.

In a cross-sectional study, Di Lorenzo *et al*[12] examined the effect of shift work on metabolic and cardiovascular risk factors in blue collar workers in Apulia, Southern Italy. The subjects were glucose tolerant males, who were all Caucasians, aged 35-60 years. All subjects underwent clinical examination and measurements of anthropometric parameters. The results showed that shift workers had significantly higher BMI compared to the non-shift workers.

A cross-sectional study of offshore personnel working on oil and gas installations in the United Kingdom investigated the effects of age and shift work exposure and their interactions with shift pattern (day shifts versus day-night rotation) as predictors of BMI.[26] There were 1,574 male workers in this study population, consisting of both day and day-night shift workers (n=787 in each group). Demographic factors, height, weight, shift pattern, years of shift work exposure and smoking habits were assessed. This study reported that continued exposure to day-night shift work was significantly associated with increases in BMI, but the effects of shift pattern on BMI depended significantly on both age and years of exposure to shift work.

Another cross-sectional study involving a working population of 27,845 people from the Västerbotten intervention program in Sweden was conducted by Karlsson *et al*.[27] The authors analysed whether shift work was associated with the metabolic syndrome, which included obesity, hypertension, and high triglycerides and other CVD risk factors. The study population consisted of day and shift workers in four age groups (30, 40, 50, and 60 years). Blood samples were taken and questionnaires were completed. The prevalence of obesity in shift workers was higher than that in day workers. Obesity and high triglycerides persisted as risk factors in shift working men and women after adjusting for age and socioeconomic factors, with an OR of 1.4 for obesity and 1.1 for high triglyceride concentrations.

Kivimäki *et al*[28] conducted a cross-sectional study to examine the associations between shift work and health habits as measured by being overweight, sedentary lifestyle, smoking, and alcohol consumption. Study samples were obtained from the 'Work and Health in Finnish Hospital Personnel' project, which involved 689 female nurses from 10 hospitals in two Finnish health care districts. The mean age of the study participants was 41.6 years. According to the results, shift workers were found to be overweight more often than day workers; however shift work was not associated with sedentary lifestyle.

To compare body fat distribution, ways of living, serum total cholesterol, serum triglyceride, blood pressure levels between 3-shift, 2-shift and day workers, Nakamura *et al*[21] conducted a cross-sectional study in Japan. Subjects were blue-collar male workers with the average length of 9.2 years shift work. The average age of shift and day workers was 34.5 and 32.7 years, respectively. Anthropometric measurements, blood collection and blood pressure were taken and self-administered demographic questionnaires were filled out. The study did not find any significance differences in BMI between the three working groups; however 3-shift workers had a higher prevalence of central obesity, which was characterised by a higher waist to hip ratio. More than half the shift workers did not exercise at all.

Cohort studies:

Niedhammer *et al*[29] conducted a longitudinal nurses' cohort observational study on 469 female nurses (mean age of 30 years) working in acute care in public sectors in France. The purpose of the study was to examine the prevalence of being overweight and weight gain in relation to night shift. Weight and height was taken by occupational physicians to calculate BMI. Demographic characteristics, exposure to night work, age, parity, smoking, and sports activities were collected from self-administered questionnaires in three consecutive time intervals (1980, 1985 and 1990). Prevalence of overweight was associated with exposure to night work in 1980 and weight gains (especially those exceeding 7 kg) were more frequent among nurses on night work than on daytime work between 1985 and 1990. The authors concluded that exposure to night work could lead to weight gain.

Studies assessing association between shift working and nutritional/dietary patterns

Cross-sectional studies:

Geliebter *et al*[14] conducted a cross-sectional survey involving 85 hospital workers to compare the prevalence of weight gain between late-shift workers and day-shift workers. The mean age and years on current shift were 43.1 years and 8.6 years, respectively. The questionnaire consisted of demographics, work and weight history, health/medical history, and also meal and sleep pattern. The findings yielded that late-shift workers reported greater weight gain than day workers. Late-shift workers showed a higher food intake compared with the day workers when combined with those reporting exercising less. However late-shift workers reported eating fewer meals. The late-shift group reported a mean weight gain of 4.3 kg, which was greater than the mean weight gain of

0.9 kg for the day-shift group (p=0.02). There were, however, no significant differences in current body mass index between groups. There was a trend for late-shift workers to report eating more since beginning the later shift (p=0.06). Late-shift workers reported eating fewer meals (1.9±0.9SD) than the day-shift workers (2.5±0.9SD; p=0.002). In addition, late-shift workers tended to eat the last daily meal later than day workers.

However, Lennernäs *et al*[34] suggested that rotating 3-shift work did not affect the nutritional quality of diet or the frequency of different types of meals and snacks. They recruited 16 healthy shift workers men, with the mean age of 34.8 years into a cross-sectional design. The subjects were interviewed five times each to reflect their twenty-four hour consumption of food on three shifts (morning, afternoon and night shifts), as well as a twelve hour shift and one day off. Outcome measures included the intake of energy and nutrients, the total number and mean frequency of types of meals and snacks, and total intake of energy, nutrients, and the content of energy and nutrients for types of meals and snacks as a function of work schedule.

Cohort studies:

To compare changes in cardiovascular risk factors between 239 shift and 157 daytime workers to identify possible cardiovascular disease risks among shift workers, Van Amelsvoort *et al*[31] conducted a one-year cohort study and changes in biological and lifestyle cardiovascular risk factors were monitored between the start of a new job and one year later. All participants were asked to complete a questionnaire about personal characteristics, current job title and job history and any objections against shift work. Anthropometric measurements and plasma cholesterol measurements were taken. Moreover, a self-administered food-frequency questionnaire was filled out for dietary assessment. The results showed that BMI decreased significantly in shift workers compared to day workers; there was a higher decrease of physical activity for respondents changing from a shift work to a day job; energy intake as well as the energy from fat and cholesterol reduced in both groups.

Reeves *et al*[20] investigated the effect of shift work on food intake and eating patterns in a cohort study. Twenty female and 16 male shift workers participated in this study. Weight and lifestyle factors were recorded and food intake was measured using a six-day food diary. The results found that there were significant differences in food intake patterns on work and rest days for night-shift workers as shift work is a factor in the timing of food consumption. However, night shift workers did not eat more than day workers. No significant differences were identified in the weights and body mass indexes of night and day-shift workers.

A cohort study investigated the influence of shift work on energy and nutrient intake in workers with very high levels of energy expenditure.[32,33] The subjects were shift workers (morning, afternoon, and night) of garbage collectors in Florianopolis city, South of Brazil. The subjects were 30.2±0.8 years old and had a BMI of 24.1±0.3 kg/m² which were not statistically different among shifts. Intake of energy and macronutrients, the frequency of ingestion and the energy derived from foods and circadian variations in energy and nutrient intake of each shift[32] and percentage of eating events and frequency of intake[33] was measured using one 24-hour recall and two 24-hour records during three non-consecutive days. No significant effect of shifts on the total, protein, carbohydrate and fat calories was reported. However shifts were found to significantly influence intake of starches, alcoholic drinks, and sweets. In different periods of the day, food and nutrient intake were also affected by shifts.[32] They reported that the total number of eating events per day was significantly higher for night shift workers.

In Japan, a cohort study on female workers in a computer factory aimed to clarify the effects of shift work on nutrient intakes in association with food consumption patterns.[19] The subjects consisted of 44 daytime workers and 93 weekly-rotating shift workers. The mean age of daytime, early-shift and late-shift workers was 28, 26 and 25 years respectively. No significant differences were found in body weight and BMI among the work groups. The intakes of energy, macronutrients, calcium and iron for 4 days (three working days and an off day) were estimated by self-registered food consumption records with the aid of a photographic method. The results showed that the amounts of energy and nutrients intakes of shift workers, particularly the late-shift workers, were smaller than that of daytime workers. The percentage of the subjects who consumed breakfast in three working days was the lowest in the late-shift workers; about 54% never ate breakfast. This finding implied that the nutritional quality of shift workers was worse, which could be attributable to poor meal quality and lower meal frequency.

Interventional studies:

Al-Naimi *et al*[30] carried out a randomized crossover study on eight healthy non-obese men aged 20-33 yrs, with a BMI between 20-25 kg/m^2, recruited from students and staff at the University of Surrey. The subjects were given a combination of two meals and a snack on two occasions following a standardized pre-study meal, simulating night and day shift working (total energy 2500 kcal: 40% fat, 50% carbohydrate, 10% protein). Meals were consumed at 01:00/ 13:00 h and 07:00/19:00h, and the snack at 04:00/16:00 h. Blood was taken after an overnight fast, and for 8 h following the first meal on each occasion. The results showed that there was a trend toward an effect of shift for plasma glucose, with higher plasma glucose at night (p=0.08), and there was a time-shift interaction for plasma insulin levels (p<0.01). Nonesterified fatty acids (NEFA) levels were unaffected by shift and greatest lipid tolerance (assessed by area under the response curve (AUC)) occurred following the mid-shift snack. In contrast, glucose tolerance was relatively impaired following the first night-time meal, with no differences observed following the second meal. Plasma insulin levels were significantly lower following the first meal (p<0.05), but significantly higher following the second meal (p<0.01) on the simulated night shift. The authors showed a raised postprandial triacylglycerol (TAG) and glucose at night, and concluded that sequential meal ingestion has a more pronounced effect on subsequent lipid than carbohydrate tolerance

Table 2. Characteristics of studies on shift working, obesity/BMI and nutritional pattern

Authors (Years)	Study design	Study population	Outcome measures	Results/Conclusion
Ghiasvand M *et al* (2006)	Cross-sectional	Four hundred and twenty four rail road workers between the ages of 21 and 64 years	BMI Total cholesterol, triglyceride and HDL-C concentration were measured after 12-hours fasting	Hypercholestrolemia and high LDL-cholesterol were significantly more prevalent in nearly all groups of shift workers irrespective of age but no differences in the serum levels of triglyceride, HDL-C, fasting blood glucose and blood pressure between shift workers and day workers was seen. Adjusted odds ratio (OR) for the effect of shift working on high serum total cholesterol and LDL-C level were 2.11 (95%CI: 1.33-3.36) and 1.76 (95%CI: 1.09-2.83), respectively.
Al-Naimi S *et al* (2004)	randomized crossover study	Eight healthy non-obese men (20-33 yrs, BMI 20-25 kg/m^2)	Meal patterns Lipid and carbohydrate tolerance, Serum glucose, insulin, triacylglycerol (TAG), and nonesterified fatty acids (NEFA)	Significant effect of shift for plasma TAG, with higher levels on simulated night compared to day shift, higher plasma glucose at night (p=0.08) and a time-shift interaction for plasma insulin levels (p<0.01). No effect on EFA levels. Raised postprandial TAG and glucose at night. Sequential meal ingestion has a more pronounced effect on subsequent lipid than carbohydrate tolerance.
Reeves *et al* (2004)	Cohort	Twenty females (10 day shift workers 10 night shift workers) 16 males (8 day shift workers, 8 night shift workers) recruited from residential nursing homes and hospitals (n=36)	Total dietary intakes of night and day- shift workers Energy intakes of female and male night-shift workers on work and rest days over 24 hours macro-nutrient composition of the diets consumed by male and female night-shift workers on work and rest days	Day staff were more likely to consume more meals per day (p<0.05) and consume fewer snacks than night-shift workers. Female night-shift workers drank more cups of tea and coffee than female day-shift workers (p<0.01). However, there were no significant differences in dietary intakes between night and day-shift workers.
Van Amelsvoort *et al* (2004)	Cohort	Subjects were from: 1) persons undergoing a pre- employment medical examination in two occupational health services; 2) all workers in a newly built waste incinerator plant; and 3) nurses, starting with practical in hospital training. (n=396)	Diet BMI Job-related factors Blood lipids Lifestyle	BMI showed a significant decrease in shift workers compared with their own baseline values, but the day workers had an increase (p=0.004). Both the shift and daytime workers groups displayed a decrease in energy intake over a 1-year period but the decrease in the daytime workers was significantly higher (p<0.001). Energy from fat and cholesterol intake were reduced in both groups, but it was insignificant (p=0.8). Analysis of respondents changing from a daytime job to a shift work job between baseline and the 1 year of follow-up (n=32) revealed a significantly higher decrease in BMI compared with daytime workers (p=0.05).
Chee *e al*.(2004)	Cross-sectional	1612 female workers from 10 large electronics assembly factories in Malaysia	BMI	Working in rotating shifts was significantly associated with being overweight (p<0.001) using a logistic regression model with all variables included as covariates. Shift workers showed significantly higher chance of being overweight (adjusted OR: 1.6, 95% CI: 1.28-2.06) even after adjusting for age and other variables.

Table 2. Characteristics of studies on shift working, obesity/BMI and nutritional pattern (cont.)

Authors (Years)	Study design	Study population	Outcome measures	Results/Conclusion
de Assis *et al* (2003a)	Cohort	Garbage collectors - city of Florianopolis (south of Brazil) during March and April 1999 (n=66 male)	Energy and macronutrients intake Frequency of ingestion and energy from food groups	No significant differences among the three shift groups for the total, protein, carbohydrate, and fat calories intake. Night shifts had a significantly higher frequency of starches intakes (p=0.0001; p=0.0003 respectively). Morning shifts ate sweets more frequently (p=0.0001).
de Assis *et al* (2003b)	Cohort	Same as population above	Dietary pattern as percentage of eating events; Energy % per eating event and per period	The total number of eating events per day was higher for night shift workers (6.2±1.2) than morning shift workers (5.3±0.2) and afternoon shift workers (5.5±0.9) (p=0.004).
Di Lorenzo *et al* (2003)	Cross-sectional	Subjects were randomly selected among male workers involved in the production process of a chemical industry in Apulia, Southern Italy. (n=319)	Anthropometric indices including BMI; waist hip ratio (WHR); systolic and diastolic blood pressure Fasting glucose; Lipid profile; insulin	Obesity was more prevalent in shift workers than in day workers (p<0.05), whereas body fat distribution was not different between the two groups. There was a significant relationship between shift work and BMI, even after taking into account fasting insulin levels (p<0.05).
Parkes (2002)	Cross-sectional	Male offshore personnel (n=1574) from 17 oil and gas installations, North Sea, UK	BMI	The increase in BMI was more marked in day-night shift group. Exposure years were correlated significantly with BMI (r=0.19, p<0025).
Karlsson, B *et al* (2001)	Cross sectional	A total of 27,485 working people from the Vasterbotten intervention program (VIP) in the North of Sweden	Obesity, lipid profiles, metabolic syndrome risk factors	Prevalence of obesity was higher amongst shift workers in all age strata of women, but only in two out of four age groups in men. Low concentrations of high density lipoprotein (HDL) cholesterol were present in the youngest age group of shift workers in both men and women. Increased triglycerides were more common among two age groups of shift working women but not among men. Obesity and high triglycerides persisted as risk factors in shift working men and women after adjusting for age and socioeconomic factors (OR=1.4 for obesity and OR=1.1 for high triglyceride concentrations).
Kivimäki *et al* (2001)	Cross-sectional	Female nurses currently or always been a shift worker, or currently permanent day workers (n=689)	Overweight Sedentary lifestyle, Smoking and Alcohol consumption	Shift workers were more often overweight than day workers (OR: 1.54, 95% CI: 1.06-2.25) and the difference between these two groups increased with age. Sedentary lifestyle was not significantly more prevalent in shift workers compared to day workers (OR: 1.31, 95% CI: 0.81-2.12).
Sudo and Ohtsuka (2001)	Cohort	Female workers in a computer factory in Yamanashi Prefecture, Japan (44 daytime workers 93 weekly-rotating shift workers n=137)	Frequencies of meals and snacks Mean nutrient adequacy rate (NAR) on 3 working days and the off day	All nutrient intakes and mean nutrient adequacy rate on working days were the highest in daytime workers and the lowest in late-shift workers. On the off day, only carbohydrate intake was significantly larger in daytime workers than in late-shift workers (p<0.017). The percentage of the subjects who took breakfast was the lowest in late-shift workers and non-meal frequency played a principal role in the low NAR energy of the late-shift workers.

Table 2. Characteristics of studies on shift working, obesity/BMI and nutritional pattern (cont.)

Authors (Years)	Study design	Study population	Outcome measures	Results/Conclusion
Nakamura *et al* (1997)	Cross-sectional	Industrial male, blue-collar workers at a personal computer and printer manufacturing company. (60 shift workers, 239 day workers, n=299)	Demographic and anthropometric characteristics (BMI, abdominal to hip girth ratio (AHR) and subscapular skin fold thickness Blood pressure and serum lipid concentrations of shift workers and day workers	3-shift and 2-shift workers had greater values of AHR and subscapular skin fold thickness than day workers, with statistically significant differences in AHR between 3-shift and day workers ($p<0.05$). There were no statistically significant differences in BMI. About 69% of shift workers did not exercise at all, while 50% of the day workers did ($p<0.05$).
Niedhammer *et al* (1996)	Cohort	Female nurses 21-58 years) working in acute care in public sector hospitals in France (n=469)	Overweight (BMI >26.9 kg/m²) Weight gain of more than 5 kg or 7 kg	Prevalence of being overweight was associated with exposure to night work in 1980 (OR: 3.3, 95% CI: 1.3-8.2). After adjustment for confounding variables, between 1985 and 1990, more nurses on night work exhibited excessive weight gains than nurses on day work; (>7 kg, OR: 2.9, 95% CI: 1.2-6.9 vs >5 kg, OR: 1.9, 95% CI: 1.0-3.6).
Lennernäs *et al* (1993)	Cross-sectional	Male shift workers age 34.8±3.0 years (24-62 years) (n=16)	Frequency of types of meals and snacks Content of energy and nutrients for types of meals and snacks	No significant variation between shifts for the content of energy and nutrients of each type of meal and snack. There was no significant variation in the frequency of meals and snacks across shifts.

DISCUSSION

Worksite nutrition strategies are emphasizing that improving workers' nutritional status can play a key role in preventing illness and promoting health and well-being.[6] Generally, with regard to published papers focusing on shiftwork nutrition, it is indicated that shift working impacts negatively on health habits and nutritional status. Recently, Antunes *et al*[35] in their systematic review have concluded that considerable epidemiological evidence support this theory that shift work is associated with increased risk for obesity, diabetes and CVD, perhaps as a result of physiological maladaptation to chronically sleeping and eating at abnormal circadian times.

Shift work has long been unrecognised as an occupational health hazard up until now. According to the research papers published in this area so far, evidence is limited with the most studies being cross-sectional. Self-reported weights and heights are of possible biases in some studies. Lifestyle patterns are other measures that should be addressed and studied in more details. It is also important to maintain homogeneity between shift group and control group for years on shift, age and medical conditions.

In this review, we have discussed on two types of studies focusing on nutritional issues in shift working. Type of study was also defined as the second categorization.

Studies assessing association between shift working and obesity and/or BMI

In Ghiasvand study,[25] there was no clear discussion on anthropometric and nutritional indices except obesity prevalence which showed no significant difference between the two night and day shift workers. The authors indicated that high serum total cholesterol and LDL-C level were more common in shift workers than in day workers and this finding persisted after adjustment for age and food type.

The subjects in Chee *et al*[18] study participated voluntarily, which could have led to biased results because the subjects may have a greater health consciousness. They measured BMI as the main study outcome but did not include dietary assessment. Confounding factors such as age, socioeconomic factors and exercise were adjusted in this study. Due to the fact that only female subjects were assessed, generalisability of the study results is limited, as it was seen in the other two cross-sectional studies[12,21] who recruited only blue-collar male workers. In the study of Di Lorenzo *et al*,[12] fasting insulin levels were controlled as confounders and BMI and WHR indices were assessed. The latter[21] did a broader adjustment on age, exercise, smoking, drinking and snacking to determine the association between three-shift work and serum total cholesterol concentration, though no odds ratios were reported.

Similarly, Kivimaki *et al*[28] recruited female subjects, although the number of subjects studied was considerable (n=689). Those subjects who drop out of work are typically less healthy, which is called the healthy worker effect and this may lead to under-evaluations of the associations. This study is also limited by its cross-sectional data and generalisability of the research results.

Parks[26] also recruited male offshore workers who had higher standards of physical and mental health, so their health status can be more favourable than in the general

working population. The increase in BMI was more marked in day-night shift group; however no odds ratio was reported. Moreover, physical activities were not taken into account when adjusting for confounders.

The Karlsson *et al* [27] study had a large representative study population (n=27,485). Age and socioeconomic situations were adequately adjusted in the multiple regression analysis to control confounders. However, the study was a cross-sectional one, hence, could not give an estimation of chronic diseases. Moreover, the definition of exposure to shift work was imperfect and did not provide information regarding patterns of shift working.

The Niedhammer *et al* [29] study may also have some potential biases including: after 10 years, 16% of the sample had been lost to follow up. Furthermore, the healthiest nurses may have been selected for night work after 10 years. These biases may have led to underestimation of the association between night work and being overweight. In addition, the duration of night work exposure throughout follow-up was not measured, which could be a more accurate indicator to assess the association between night work and being overweight. On the other hand, the confounders were well controlled for, such as age, weight at baseline and regular sport activities. The authors also calculated odds ratios to compare the weight gains between day and night shift workers.

Studies assessing association between shift working and nutritional/dietary patterns

The Al-Naimi *et al* [30] study had a two-way randomized crossover design on eight male subjects which is unique in this area. The food intake of the participants was controlled for 6 hours before each study day/night, with a standardized meal and snack. They also measured the postprandial hormone and metabolite responses as the total AUC, using the trapezoidal rule. The study was designed to compare the metabolic effects of meals on simulated day and night shifts under conditions where participants were not adapted to nightshift work. There was no clear conclusion at the end of their paper. However, as the final suggestion, the authors indicated that restriction of dietary fat intake throughout the night would be beneficial in night-shift workers who are not adapted to night time working. The sample size of this study may limit its generalisability.

In the Reeves *et al* [20] study, the author stated that there were significant differences in food intake patterns on work and rest days for night-shift workers. They also mentioned that shift work is a factor in the timing of food consumption. However, there were no significant differences in weights and body mass indexes of night and day shift workers. The strength of this study is that under-reporters were excluded if the energy intakes were less than 1.5 times Basal Metabolic Rate and there was a loss in body weight. It is to remember that the sample of this study was small (n=36).

van Amelsvoort *et al* [31] in their prospective cohort study, assessed the impact of shift work on cardiovascular disease risk factors in shift workers during a one-year period. At the end-point of the study, only the data from workers who remained in the same work schedule were presented (264 out of 396) and those changed their work schedules were not included. This could lead to a selection bias and a possible underestimation of the findings. On the other hand, measurement bias was also possible because the researchers carried out the measurements in different phases of the circadian rhythm. Furthermore, the baseline measurements were taken in a wide time range (between 1 and 8 weeks after the start of a new job), hence, during this period, some adaptations could have happened. Shift workers were older than day workers, but it was not adjusted for as a confounder. It seems that to observe significant changes in cardiovascular disease risk factors, a longer follow-up time is needed.

Three studies by de Assis *et al,*[32,33] Sudo and Ohtsuka[19] and Lennernäs[34] had a similar limitation according to their one-gender selection bias and also the relatively small study sample which may underestimate some results.

Findings of Lennernäs,[34] as the only study reporting that shift work had no effect on nutritional status, should be interpreted with caution as the sample size was very small, recruiting only 16 male workers and the study design was cross-sectional.

Accordingly, the external validity and generalisability of these studies to all shift workers remain to be further cleared.

The sample size was also relatively small (n=85) in Geliebter *et al* [14] study. Moreover, it had a cross-sectional design. The data on subjects' weights relied on self-report and some data were based on the individuals' memories for about more than eight years ago. However, the authors argued that the accuracy of data among the three groups studied could be regarded similar. The results showed that late-shift workers took more and longer naps; and the authors discussed that more weight gain could be resulted from decreased energy expenditure during the naps. However this was not adjusted for as a confounding factor. [36]

Finally, it is worthy to note that all cohort studies, except Van Amelsvoort *et al* [31] which reported a decreased BMI in shift workers, have indicated no significant differences in BMI or body weight between shift works and day-workers.

In the findings, we see that in the first category of studies looking at the BMI, weight gain and/or obesity prevalence, 6 out of 7 cross-sectional studies and one cohort study showed a higher BMI/obesity prevalence in shift workers. From the second category looking at the dietary pattern, one out of two cross-sectional studies has indicated a higher food intake in shift workers and two out of four cohort studies have emphasized a higher meal intake and/or lower nutrition quality in shift workers. Moreover, greater weight gain was also reported in one of the latter two cross-sectional studies.

To sum up, as indicated in most studies, shiftwork can potentially change the food intake patterns in ways that may be unfavorable to health and this risk can be prevented by using appropriate interventions such as nutrition education programs. [37]

Conclusion

In this review, a number of studies in the literature were presented in which the association between shift working

and workforce' nutritional status has been discussed and possible health hazards were addressed. Evidence from most studies revealed that shift working affects nutritional intake in a negative way.

Regarding nutritional strategies for shift workers, although there are some general advices available in non-scientific and commercial websites, however, no clear recommendations have been published in this area so far. Hence, it seems that in addition to general guidelines, we need more practical and specialized recommendations to meet the workers' nutritional requirements in different settings with various conditions.

Understanding the impact of shift work on health and nutritional status of staff and accordingly economic productivity, should be highlighted in every long term industrial strategic plan. Local circumstances (such as hot environment or workers exposures) and modified nutritional needs (such as high energy expenditures or obesity prevalence) should also be considered.

As a field of future works, greater use of nutritional frameworks for interventions that acknowledge the complexity of the environment and specific nutritional requirements is suggested.

AUTHOR DISCLOSURES

The authors have no conflicts of interest.

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Review Article

Shiftworking, nutrition and obesity: implications for workforce health- a systematic review

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輪班制、營養及肥胖：對於員工健康之意涵 -系統性回顧

背景：直到近期，輪班制才被視為職業健康的危害因子之一。方法：利用 OVID 搜尋網做為電子資料庫的主要搜尋引擎，搜尋 Medline、PUBMED 和 CINHAL 上，從 1990 年至 2010 年 12 月期間發表的文章。藉由關鍵字組合，共搜尋到 35 篇全文和摘要，其中相關文章有 16 篇。但有一篇為非英文撰寫，因此最後決定收納 15 篇。將這些研究分成兩個主題：8 篇探討關於輪班工作制和肥胖和/或身體質量指數之間的相關性；另 7 篇則探討輪班制和營養/飲食型態之相關性。進行搜尋時亦考慮研究的類型。結果：在收納文獻中，包含 1 篇介入性、9 篇橫斷性和 5 篇世代型研究。由 7 篇橫斷性和 1 篇世代研究結果顯示，輪班工作者有較高的身體質量指數/肥胖盛行率；介入性、1 篇橫斷性和 3 篇世代研究結果指出，輪班工作者比起日班工作者，有較高的用餐頻率或較差的營養品質/習慣。另一篇橫斷性研究則顯示，兩種工作制之間並無顯著差異。結論：就肥胖或高身體質量指數而言，大部分橫斷性研究指出，輪班工作會使體重增加幅度加大並提高肥胖盛行率。另一方面，有一半的世代研究顯示輪班工作者有較高的用餐頻率和/或較差的營養品質。總的來說，輪班工作對於員工的健康和營養狀態有負面影響。

關鍵字：輪班工作制、營養、肥胖、勞動力、系統性回顧