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Night Shift Work, Diet, Meal Timing, and Cardiometabolic Risk: An Exploratory Cross-Sectional Study in Italian Cement Workers

Maura Minonzio [1,†], Ilaria Capitanelli [2,†], Nicola Magnavita [3], Saverio Stranges [4,5], Chiara Arienti [6] and Franca Barbic [1,6,*]

1 IRCCS Humanitas Research Hospital, via Manzoni 56, 20089 Milan, Italy
2 Department of Public Health, Azienda Sanitaria Locale Roma 1, 00167 Rome, Italy
3 Department of Life Sciences and Public Health, Università Cattolica del Sacro Cuore, 00168 Rome, Italy
4 Department of Epidemiology and Biostatistics, Schulich School of Medicine & Dentistry, Western University, London, ON N6A 3K7, Canada
5 Department of Clinical Medicine and Surgery, University of Naples Federico II, 80138 Naples, Italy
6 Department of Biomedical Sciences, Humanitas University, 20072 Pieve Emanuele, Italy
* Correspondence: franca.barbic@hunimed.eu
† These authors contributed equally to this work.

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Abstract: Rotating shift work, including night shifts, is reported by one-fifth of workers in the EU27 survey and is associated with an increased risk of cardiovascular disease. Irregular meal timing and poor dietary habits related to shift work contribute to metabolic disorders and may further elevate cardiovascular risk. In this pilot study, 14 rotating shift workers including night shifts (NSWs) and 14 regular daytime workers (DWs) underwent assessments of blood pressure, body mass index (BMI), waist (W) and hip (H) circumference, triglycerides, HDL, and LDL cholesterol. All participants also completed questionnaires evaluating nutrient quality, meal timing over a week, and lifestyle factors. In NSWs, a disrupted eating schedule was observed during both workdays and rest days, with frequent lunch skipping in favour of high-fat snacks. Weekly intake of junk food was higher ($p < 0.01$) and fresh vegetable consumption lower ($p < 0.05$) in NSWs compared to DWs. BMI, W/H ratio, and triglyceride levels were slightly higher in NSWs. Active smoking was more common among NSWs (50%) than DWs (21%, $p < 0.01$). Excess body weight, dyslipidemia, and higher smoking prevalence—combined with a long-standing pattern of unhealthy eating may, along with circadian misalignment, contribute to the elevated cardiometabolic risk observed in otherwise healthy NSWs. Implementing workplace policies to improve nutrient quality and meal timing may help reduce the risk of cardiometabolic disorders in this population.

Keywords: shift work; eating time; cardiometabolic risk; metabolic syndrome; nutrients

1. Introduction

Shift work, including night shifts, was reported by 21% of workers in the 2021 EU27 survey [1]. This work pattern is a core organizational feature in various sectors such as manufacturing, social and healthcare services, hospitality, retail, public administration and defence, and transportation. It extends the traditional 8-h daytime schedule by alternating worker groups over a full 24-h period, including nighttime. Both historical and recent large cohort studies have shown that night shift workers have a higher risk of cardiovascular [2–6] and metabolic diseases, including obesity, insulin resistance, dyslipidaemia, and diabetes [5,7–10], compared with daytime workers.

Circadian misalignment in NSWs results from continuous changes in the daily allocation of sleep, leisure, and work, which are not synchronized with biological rhythms regulating metabolism [8,9]. These mechanisms are governed by the endogenous clock, strongly linked to the light–dark cycle [11–14]. Long-term night shift work and the related sleep deprivation disrupt melatonin secretion, which is promoted in darkness but suppressed by nighttime light exposure [10]. Melatonin influences the cycles of cortisol, insulin, leptin [11,15–17], and ghrelin [18], and alterations in these patterns can impair glucose and lipid regulation, promote adipose tissue accumulation, oxidative stress, and inflammation [11,19]. Both fat depositions, via lipoprotein lipase, and fat mobilization, via hormone-sensitive lipase, follow circadian rhythms in white adipose tissue in humans and laboratory animals [20].

Rotating shift work, including night shift, may disrupt the eating patterns by altering meal composition, timing, and energy intake [21,22]. This may impact on cardiometabolic risk and promote cardiovascular diseases in several working populations.

Addressing circadian disruption is a promising approach to preventing chronic diseases linked to night shift work [8]. The Total Worker Health (TWH) approach, endorsed by the U.S. National Institute for Occupational Safety and Health (NIOSH) [23], combines assessment of occupational hazards with evaluation of worker health and lifestyle, diet, sleep, physical activity, smoking, alcohol consumption to design targeted, multidisciplinary interventions [23,24].

Based on the above considerations, the aim of the present pilot study was to compare dietary habits, metabolic profile, and sleep patterns in two age- and sex-matched groups of cement plant workers with similar occupational exposure profile but different working schedules. One group consisted of workers engaged in rotating shift work including night shifts (NSWs), while the other group followed a regular daytime work schedule (DWs).

2. Materials and Methods

As part of the planning phase for a survey on cardiometabolic risk factors among night shift workers, we carried out a preliminary cross-sectional study on the workforce of a large cement plant in Northern Italy operating continuously on a 24-h cycle. The total workforce comprised 115 employees, 30 of whom worked in a rotating schedule of daily 8-h shifts, seven days a week: morning (M: 6:00–14:00), afternoon (A: 14:00–22:00), and night (N: 22:00–6:00), followed by two rest days (R). This rapid forward-rotating scheme followed the sequence MM–AA–NN–RR. The remaining workers had a standard daytime schedule from 8:00 to 17:00, five days per week. Among daytime workers, 24 performed tasks with physical and mental demands similar to those of night shift workers.

During the annual occupational health examination, blue-collar NSWs and DWs with comparable physical and mental workloads were invited to participate. The inclusion criteria were having at least five years of work seniority. All the enrolled subjects had to be judged fit for specific job task by the occupational physician in charge. The exclusion criteria were the presence of already diagnosed ischemic cardiac disease, dyslipidaemia under treatment, diabetes and other chronic diseases.

Twenty-two NSWs and 16 DWs, all males aged 30–59 years, consented and signed a written informed consent form allowing access to their health records and relevant record-linkage, in compliance with the Italian Personal Data Protection Law (Law Decree 10 August 2018, N. 101).

All subjects underwent a complete clinical evaluation. The body mass index (BMI) was calculated using Quetelet's index, following World Health Organization (WHO) recommendations. Blood pressure and heart rate were measured three times with a sphygmomanometer [25]: first in a supine position and then after three minutes of active standing. Venous blood samples, collected early in the morning after fasting from midnight, were analysed for glucose and lipid profile, including high-density lipoproteins (HDL), triglycerides, and low-density lipoproteins (LDL).

After training provided by the lead researcher, participants completed two questionnaires: a lifestyle and dietary habits questionnaire, and an adapted Italian version of the Survey of Shift Workers (SOS) questionnaire [12]. Questionnaires were completed in a dedicated room without time limits, with the researcher available for clarification. The lifestyle and dietary questionnaire consisted of four sections:

(1) Demographics.
(2) Work-related data and current tasks, year of employment start, shift type, commuting distance/time, transportation mode, satisfaction with social/family life, and perceived work-related fatigue.
(3) Health-related data, bowel habits, digestive symptoms, and psychological disorders.
(4) Eating habits, meal preparation location and a Food Frequency Questionnaire (FFQ) [26] covering a wide range of food items, condiments, and beverages. Frequency categories were never, 1–3 times/month, 1–2 times/week, 3–4 times/week, 5–6 times/week, and 1–4 times/day.

A "Junk Food" category [27] was defined as items high in calories, low in nutrients, and rich in additives, including fried chips, sausages, snacks, sandwiches, and ready-made pizza/meals. The adapted SOS questionnaire also assessed sleep quality/duration and levels of sleepiness/alertness at work [12].

Data were collected between March and November 2019.

Statistical analyses used parametric or non-parametric measures of central tendency, as appropriate. The null hypothesis was rejected when the *p*-value was <0.05.

Ethics Approval

The study was conducted in accordance with the Declaration of Helsinki (2013 revision). Written informed consent was obtained from all participants. Data were collected as part of mandatory health surveillance, in compliance with Italian privacy law and health promotion protocols. The plant's Occupational Health and Safety (OHS) unit, which includes the employer or representative, OHS officer, occupational physicians, and two elected worker representatives, approved the study.

3. Results

After excluding subjects with cardiometabolic disorders or other chronic diseases, 28 workers—14 DWs and 14 NSWs—completed data collection. Table 1 summarises the demographic and clinical characteristics of participants by work shift type. Job seniority was higher among DWs compared to NSWs. The average BMI for both groups was in the overweight range. NSWs were more likely to be married, while the average number of children did not differ. NSWs smoked more frequently and engaged in less leisure-time physical activity than DWs, although alcohol consumption was similar. On average, NSWs had been working rotating night shifts for 16 years (range: 2–29).

Table 2, Figures 1 and 2 present the hemodynamic and metabolic parameters of the participants. Obesity was observed in two NSWs. Mean fasting blood glucose and total cholesterol levels were within normal limits, but NSWs showed higher triglyceride levels and slightly lower HDL cholesterol than DWs.

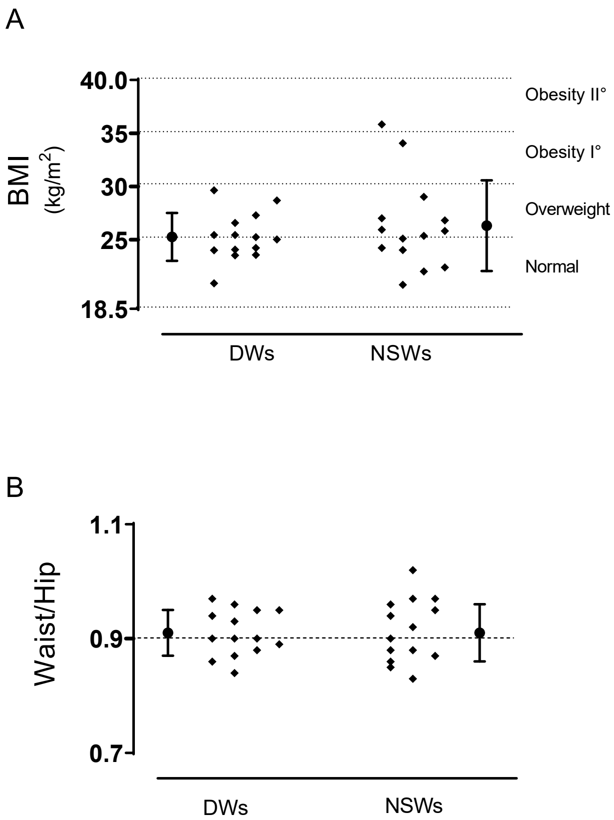

Figure 1. Individual values (black squares) of Body Mass Index (BMI) (panel (**A**)), and Waist/Hip (panel (**B**)) in Daytime Workers (DWs) and Night Shift Workers (NSWs). Dashed line in panel (**A**) shows the classification of BMI according to WHO guidelines. Dashed line in panel (**B**) indicates the upper limit for the increased metabolic risk in men.

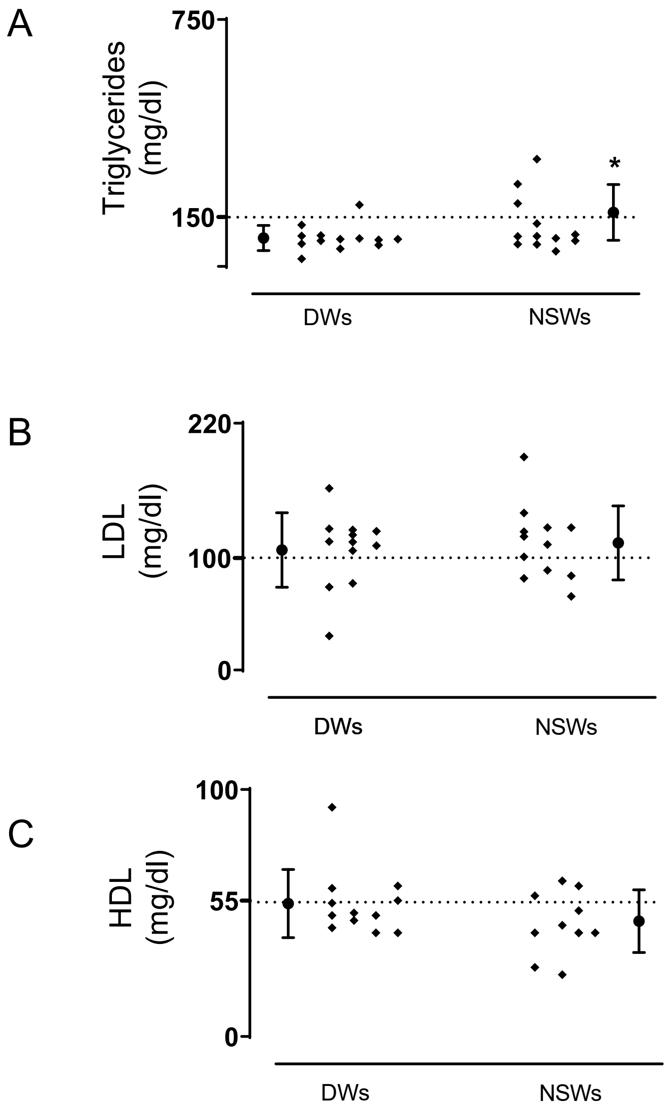

Figure 2. Individual values (black squares) of Triglycerides, LDL and HDL in Daytime Workers (DWs) and Night Shift Workers (NSWs). Three NSWs presented high values of triglycerides, the majority of NSWs have higher values of LDL and lower values of HDL. Dashed lines in panel A, B, C indicate the upper limits of the normal values of triglycerides, LDL and HDL respectively as indicated by the laboratory. * p <0.05.

Blood pressure readings were within the normal range for all participants according to the 2023 European Society of Cardiology (ESC)/European Society of Hypertension (ESH) guidelines [25]. No cases of orthostatic hypotension were identified. However, standing heart rate was significantly higher in NSWs, while other hemodynamic variables were similar between groups. The Systematic Coronary Risk Evaluation 2 (SCORE 2) [19] values were comparable.

In both groups, dietary patterns deviated from WHO recommendations [28,29]. As shown in Table 3, NSWs had a significantly higher weekly intake of Junk Food and lower intake of fresh vegetables than DWs. Consumption of sugary drinks, soft drinks, and wine was also greater among NSWs.

Analysis of weekly meal timing (Figure 3) showed that NSWs had irregular eating schedules throughout the week, not only on workdays (orange squares) but also on rest days (blue squares). In contrast, DWs maintained a regular three-meal routine on both workdays and rest days. NSWs often skipped lunch or replaced it with snacks, and during night shifts tended to eat only two meals within a short interval.

Half of the NSWs reported negative impacts on family life and social relationships, and 50% experienced increased anxiety episodes compared to 16% of DWs (p = 0.043). All DWs felt sufficiently rested before starting work shifts, whereas 25% of NSWs did not. SOS questionnaire results indicated that NSWs did not get adequate rest between consecutive morning shifts, though they reported restorative sleep between afternoon and night shifts.

Mean sleep duration between consecutive morning shifts was 6.1 ± 0.3 h, compared to 7.9 ± 1.8 h between afternoon shifts and 5.5 ± 0.93 h between night shifts. Afternoon shifts were perceived as less fatiguing and allowed for better sleep. DWs reported good sleep quality, averaging 7.7 ± 0.6 h, and none experienced significant gastrointestinal symptoms.

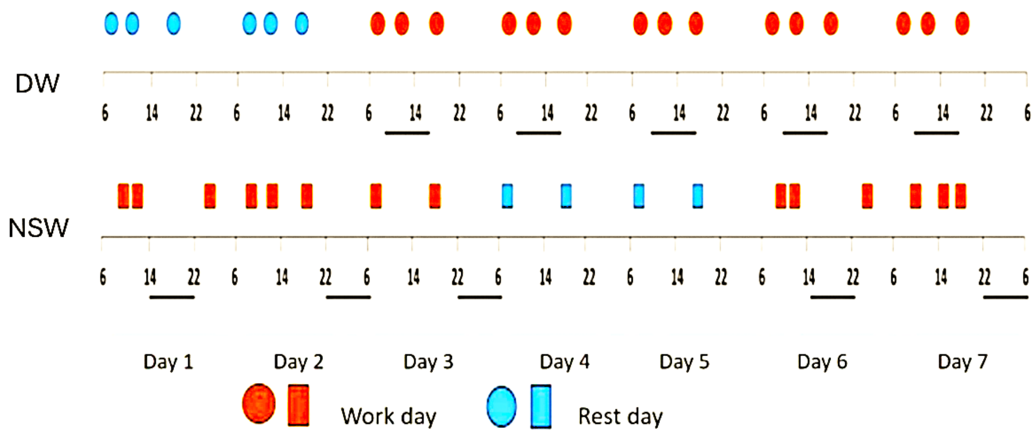

Figure 3. Example of a typical meal timing pattern over a week in a Day Worker (DW, circles) and in a Night Shift Worker (NSW, squares). The orange symbols indicate working days, while the blue ones indicate the rest days.

Table 1. Demographics and clinical characteristics in daytimes workers (DWs) and in nightshift workers (NSWs).

Demographics and Clinical Characteristics	DWs (*n* = 14)	NSWs (*n* = 14)	*p* Values
Age [yrs], mean (sd)	51(9)	50 (5)	0.94
Seniority [yrs], N (sd)	24 (9)	16 (9)	0.02
Night shift/year, N (sd)	NA	85 (5)	
Education, N (%)			
High school	9 (67)	11 (75)	0.27
Junior school	5 (33)	4 (25)	0.27
Married, N (%)	7 (50)	10 (75)	<0.001
Number of children, N (sd)	2.3 (0.6)	2.0 (1.0)	0.79
Regular physical activity, N (%)	9 (67)	7 (50)	0.02
Smokers, N (%)	3 (21)	7 (50)	<0.001
Cigarettes/day N (sd)	8.3 (2.9)	11.5 (7.4)	0.69
Alcohol drinkers *, N (%)	10 (71)	10 (71)	1
Regular use of medications, N (%)	5 (36)	3 (21)	0.02

* Less than 14 units a week on a regular basis.

Table 2. Hemodynamics and metabolic parameters in daytimes workers (DWs) and nightshift workers (NSWs).

Variables	DWs (*N* = 14)	NSWs (*N* = 14)	*p* Values
Body Mass index (kg/m^2, mean, sd)	25.7 (2.7)	27.4 (5.0)	0.40
Waist circumference (cm, mean, sd)	92.3 (9.2)	94.0 (12.7)	0.51
Hip circumference (cm, mean, sd)	101.6 (5.9)	101.9 (8.1)	0.51
Waist/Hip	0.9 (0.1)	0.9 (0.0)	0.82
Systolic Blood Pressure			
Supine (mmHg, mean, sd)	130 (12)	130 (16)	1.00
Standing (mmHg, mean, sd)	128 (11)	128 (16)	0.92
Diastolic Blood Pressure			
Supine (mmHg, mean, sd)	80 (6)	81 (8)	0.71
Standing (mmHg, mean, sd)	90 (6)	90 (7)	0.87
Heart Rate			
Supine (bpm, mean, sd)	67 (7)	71 (11)	0.31
Standing (bpm, mean, sd)	78 (8)	86 (9)	0.02
Blood tests			
Glycaemia (mg/dL, mean, sd)	90.8 (12.7)	87.7 (5.1)	0.20
Triglycerides (mg/dL, mean, sd)	86.2 (38.4)	164.3 (85.0)	0.005
Total Cholesterol (mg/dL, mean, sd)	175.1 (39.1)	174.3 (33.6)	0.19
HDL (mg/dL, mean, sd)	53.8 (13.8)	46.7 (12.7)	0.14
LDL (mg/dL, mean, sd)	107.1 (33.2)	113.3 (33.0)	0.65
SCORE2 *	4.3 (1.7)	5.1 (2.3)	0.30

Note: abbreviations are explained in the text; * Framingham Heart Study [19].

Table 3. Weekly food intake in daytimes workers (DWs) and nightshift workers (NSWs) expressed as average weekly servings (standard deviation).

Food/Beverage Items	DWs (*N* = 14)	NSWs (*N* = 14)	*p* Values
Junk food	2.6 (1.3)	5.5 (2.9)	0.019
Vegetables	6.8 (3.5)	1.8 (2.4)	0.005
Fruits	5.9 (4.6)	6.5 (5.5)	0.87
Bread	4.2 (2.8)	4.7 (2.7)	0.75
Pasta/rice	4.2 (2.7)	2.5 (1.1)	0.23
Baked goods	4.0 (3.0)	2.0 (1.7)	0.22
Potatoes	1.3 (1.2)	0.5 (0.0)	0.14
Meat	2.0 (0.9)	1.6 (0.8)	0.36
Cured meats	1.9 (1.4)	3.0 (1.1)	0.37
Fish	1.3 (1.2)	1.2 (0.5)	1.00
Eggs	0.7 (0.6)	1.2 (0.5)	0.20
Legumes	1.1 (0.6)	1.7 (0.5)	0.39
Dairy	1.1 (1.4)	2.5 (3.1)	0.44
Cheese	1.4 (1.1)	2.1 (2.2)	0.46
Wine/beer	1.1 (1.0)	1.3 (1.1)	0.70
Sugary drinks *	0.6 (0.7)	2.0 (2.8)	0.08
Coffee	11.6 (10.1)	14.5 (8.7)	0.40

* Sugary drinks (also categorized as sugar-sweetened beverages or “soft” drinks) refer to any beverage with added sugar or other sweeteners (high fructose corn syrup, sucrose, fruit juice concentrates, and more). This includes soda, pop, cola, tonic, fruit punch, lemonade, sweetened powdered drinks, as well as sports and energy drinks (WHO 2023).

4. Discussion

This pilot study was conducted to support the planning phase of a larger survey aimed at characterizing the cardiometabolic risk profile of night shift workers, information that is highly relevant for occupational health professionals in designing targeted interventions to reduce cardiovascular risk associated with shift work. The findings will also help estimate the statistical power needed to test key hypotheses and refine study protocols and questionnaires.

We examined 28 male cement plant workers equally divided into NSWs and DWs. They shared the same work environment and engaged in jobs with similar physical and mental strain.

The main findings of the present study were:

(1) NSWs consumed more unhealthy food and fewer vegetables per week.
(2) NSWs showed irregular meal timing patterns during both work and rest days.
(3) NSWs slept less and reported poorer sleep quality.
(4) NSWs experienced greater disruption to family and social life.

While some dietary and lifestyle differences were not statistically significant, NSWs consistently exhibited unhealthier eating habits, altered lipid profiles, and qualitative and quantitative sleep disturbances. Processed foods and sugary drinks, which provide few micronutrients but are high in fat and/or sugar [27–29], were more prevalent in the NSW diet. Macronutrient analysis confirmed excessive fat intake in respect of the WHO recommended levels [28,29]. In addition, sleep disruption likely increased appetite and energy intake, particularly from snacks and foods high in fat and carbohydrates, as previously described [30,31]. Over time, such behaviors can contribute to cardiometabolic diseases [31–33], consistent with the slight increase in Framingham cardiovascular risk scores observed [19]. The findings of the present study are in line with those of Lotti et al. [30], who reported lower adherence to the Mediterranean diet, poorer sleep quality, and higher levels of anxiety and stress among NSWs. The cardiometabolic risk profile was also slightly elevated among DWs. However, compared to the DWs, the NSWs in the present study smoked more frequently and exhibited higher triglyceride levels along with lower HDL cholesterol. The NSWs reported shorter and less restorative sleep, and their eating patterns were irregular both during the work week and on days off, poorly synchronized with the sleep–wake cycle. The irregular eating schedule in NSWs persisted even on rest days, suggesting a chronic misalignment between eating times and the sleep–wake cycle.

In a recent study, Zhao et al. [8] found that night shift workers experienced larger infarction sizes and had a higher risk of subsequent major cardiac events compared with a group of age and sex matched the day workers. In addition, an experimental simulation of shift work in mice and sheep, showing an increased frequency of reperfusion injury, suggested their link with circadian disruption [8]. Of interest, the cardiometabolic risk profile of these night shift workers was similar to what observed in the NSWs of the present study.

The analysis of dietary questionnaire showed that NSWs of the present study had higher consumption of "junk" foods and sweet beverages, and lower vegetables intake compared to DWs. Junk foods and sweet beverages contribute a few micronutrients to the diet, contain substantial amounts of fat and/or sugar and are high in energy [27–29]. As expected, the detailed analysis of the macronutrients' composition of meals found that shift workers reported higher than recommended levels of fat [28].

Previous studies have shown that eating at biologically inappropriate times impairs glucose and lipid regulation, reduces insulin sensitivity, and promotes abdominal fat accumulation [17,20]. High-fat meals eaten at irregular times may also disturb the secretion of leptin, ghrelin [11,16], and insulin, all of which are under circadian control [11,16,18].

Of interest, NSWs in this study also tended to skip meals during rest periods. Several mechanisms have been suggested for explaining this observation. The blunting of the normal daytime peaks of appetite and digestive readiness, which reduces or mistimes appetite during the worker's daytime 'rest' period, may promote meal skipping. Sleep loss, that alters hormones that control hunger and satiety [11,16,18], also can suppress appetite at sometimes promoting snacking at night and skipping main meals during the day. Finally, stress, fatigue, low mood, and cognitive load from shift work can suppress appetite or make meal planning/preparation feel burdensome, leading to skipped meals during rest periods [34–36]. Workers on rotating shifts, including night ones, experienced the autonomic nervous system unbalance because they must be active at night when physiologically the body metabolic activity is lower and rest/sleep during daytime [13]. Indeed, in daily workers, the parasympathetic activity is generally heightened during the evening and night when the individual is typically at rest [13,37]. Conversely, during daytime and when actively engaged, sympathetic activity prevails and promotes catabolic processes to provide energy for the body in stressful or high-demand situations [13]. Under physiological conditions, i.e., regular wake-sleep activity according with the light-dark cycle, parasympathetic activity stimulates insulin release from pancreatic beta cells which in turn promote anabolic processes related to glucose and fat metabolism [38–44]. The increase in glucose uptake into cells for energy or storage promotes synthesis of fat and inhibits lipolysis [17,45–47] .

This autonomic imbalance negatively affects how the body processes food, stores fat, and utilizes energy toward the development of chronic conditions such as overweight, metabolic syndrome, and hypertension [17,20,38].

The circadian clock and nutrient metabolism are closely linked [48–52], with regular sleep–wake cycles supporting metabolic health, and consistent meal timing reinforcing circadian stability [16,46,53]. Therefore, the disruption of circadian rhythms, combined with altered lifestyle habits—such as irregular eating, increased smoking, and poor sleep patterns—reported more frequently by NSWs than by DWs of this study, may create an unfavorable metabolic phenotype that facilitates the development and progression of metabolic alterations and related diseases [34]. This is also consistent with what has been found in previous clinical trial and animal studies [10,18,41].

The effects of rotating night shift schedules may vary across working populations, reflecting the complex interplay of workplace environments, occupational demands, and additional non-occupational responsibilities, such as family caregiving. For this reason, the intervention for reducing the cardiometabolic risk factors and for globally promoting health should be tailored to the specific target working population.

Based on the above observations, preventive strategies in our study population should be tailored: for both DWs and NSWs, with a focus on nutrient quality and quantity in relation to job-related energy demands; for NSWs, incorporating also workplace facilities that promote regular, healthy food intake both on- and off-duty. A tailored physical activity program that accounts for the level of occupational physical activity among NSWs [54,55] should be proposed to help reduce the risk of cardiometabolic diseases in this population. The timing of physical activity should also be adapted to their varying work shifts and rest days.

Occupational physicians can play a key role in preventing overweight, obesity, and related chronic diseases by addressing both occupational risk factors and lifestyle [56–60]. This approach aligns with the NIOSH Total Worker Health hierarchy of controls model, which emphasizes that workplace interventions are more effective when hazardous working conditions are first addressed and mitigated, rather than encouraging only personal behavior changes [23,57]. Multifaceted interventions, simultaneously promoting health-enhancing policies and practices, redesigning the work environment and organization, and educating workers on safety and health, lie in the middle [23,24,61]. Many workplaces Health Promotion Programs implemented in past decade have been at least partially ineffective due to a lack of assessment of occupational and socioeconomic conditions [59,60]. Factors such as administrative vs. manual tasks, low vs. high physical load, low vs. high work-related stress, and varying levels of education have been frequently overlooked [35,36].

The possibility of interrupting periodically the NSW schedule by introducing regular DW or by removing the more susceptible workers to cardiometabolic risks may be considered as additional interventions in the workplace. Finally, workplace facilities aimed at promoting healthier dietary patterns to cope with the energy required by the job task and starting from the tailored proposal in the workplace may further reduce the cardiometabolic risk in this population. This might be obtained by adequate food distribution program in terms of timing and quality of nutrients possibly provided by the employers. A recent randomized trial by Chellappa et al. [61], who used a simulated night work protocol in a young group of workers, suggested that interventions characterized by forcing eating only during daytime might mitigate some biomarkers of cardiovascular risk. In addition, considering the results of the present study, NSWs should be educated to eat healthier food and beverages during their rest days and to follow sleep hygiene measures [30,37,42,62].

In summary, circadian disruption combined with irregular eating, increased smoking, and poor sleep, more common in NSWs, may foster an adverse metabolic profile and raise cardiometabolic disease risk [8,32,41]. This is consistent with prior clinical and experimental evidence [10,18,53] and require ad hoc interventions starting from workplace organization and facilities provided a well-defined program for assessing their effectiveness

Limitations

This pilot study has two main limitations: its cross-sectional design and small sample size. The former limits the ability to infer causal relationships, even when findings are consistent with those from large-scale studies. Nevertheless, cross-sectional designs can provide valuable insights within a reasonable timeframe and serve as a basis for randomized controlled or prospective intervention trials to test hypotheses and implement preventive measures.

The small sample size was consistent with the exploratory aim of the study. We are aware that statistical inference is particularly vulnerable to misinterpretation. Limited power reduces the likelihood of detecting true effects, and when statistical significance is achieved, effect sizes are often overestimated due to sampling variability, reflecting substantial uncertainty. For this reason, our findings should be interpreted with caution. However, rather than definitively testing hypotheses, our goal was to evaluate the data collection tools and estimate the magnitude of differences between DWs and NSWs for accurate power calculations in future research. We matched the two groups by age, sex, and physical and mental workload, and only included individuals certified as fit to work, excluding those with cardiometabolic or other chronic conditions. This increased confidence that observed differences in diet quality and meal timing were related to work schedule, while minimizing confounding factors. However, other confounding factors, such as socioeconomic status and variations in shift rotation schedules, should also be considered in future larger studies.

The sleep quality questionnaire provided only general information, and chronotype was not assessed. Since chronotype can influence both meal timing and dietary composition during work and rest days [21], it should be included in future research. Combining a Food Frequency Questionnaire with a weekly diet diary would also improve the accuracy of data on dietary habits, covering quality, frequency, timing, and regularity of meals both on- and off-duty. Finally, as widely discussed, the results of the present study are limited to male cement plant workers.

5. Conclusions

This pilot study indicates that NSWs display lifestyle and metabolic characteristics that may increase cardiometabolic risk. Compared with DWs, NSWs had higher intake of unhealthy foods, lower vegetable consumption, and irregular meal timing persisting on rest days. These dietary patterns, combined with shorter and lower-quality sleep, higher smoking prevalence, and subtle lipid alterations, suggest an emerging unfavourable metabolic phenotype. Circadian misalignment may exacerbate these effects by disrupting insulin sensitivity, appetite regulation, and energy metabolism. The findings emphasize the importance of workplace interventions promoting regular, balanced nutrition and restorative sleep. Occupational physicians and employers should implement strategies integrating environmental support, health promotion programs, and individualized guidance to mitigate cardiometabolic risks in shift workers. Longitudinal studies are needed to clarify causal links between shift work, meal timing, and metabolic outcomes, while intervention trials can assess the effectiveness of workplace strategies to improve diet, sleep, and overall cardiometabolic health in night shift populations.

Author Contributions

F.B. and M.M.: conceptualization of the study; M.M. and I.C. methodology collecting data and analyses; F.B. and C.A.: data curation. M.M. and I.C.: writing—original draft preparation; F.B.: supervision; F.B, N.M. and S.S.: writing—reviewing and editing. All authors have read and agreed to the published version of the manuscript.

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This research received no external funding. Heidelberg Materials provided facilities for collecting data and interviewing the workers.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki Ethical review and approval were waived for this study because it was part of the health surveillance in workplace as a mandatory duty requested by the Italian law. The study received the approval of the internal Company Board of Health and Safety that includes representatives of workers.

Informed Consent Statement

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Data Availability Statement

The data set used in this study will be available, after publication, by our subjects-based data repository Zenodo.

Acknowledgments

We thank the workers of the cement plant who agreed to participate in the study and the cement plant for providing facilities for collecting data.

Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

References

1. EU-OSHA. Available online: https://oshwiki.osha.europa.eu/en/themes/working-time (accessed on 15 June 2025).
2. Knutsson, A.; Jonsson, B.G.; Akerstedt, T.; et al. Increased risk of ischaemic heart disease in shift workers. *Lancet* **1986**, *328*, 89–92.
3. Åkerstedt, T.; Knutsson, A.; Alfredsson, L.; et al. Shift work and cardiovascular disease. *Scand. J. Work. Environ. Health* **1984**, *10*, 409–414.
4. Torquati, L.; Mielke, G.I.; Brown, W.J.; et al. Shift work and the risk of cardiovascular disease. A systematic review and meta-analysis including dose-response relationship. *Scand. J. Work. Environ. Health* **2018**, *44*, 229–238.
5. Ferguson, J.M.; Costello, S.; Neophytou, A.M.; et al. Night and rotational work exposure within the last 12 months and risk of incident hypertension. *Scand. J. Work. Environ. Health* **2019**, *45*, 256–266.
6. Vetter, C.; Devore, E.E.; Wegrzyn, L.R.; et al. Association Between Rotating Night Shift Work and Risk of Coronary Heart Disease Among Women. *JAMA* **2016**, *315*, 1726–1734.
7. Rosa, D.; Terzoni, S.; Dellafiore, F.; et al. Systematic review of shift work and nurses' health. *Occup. Med.* **2019**, *69*, 237–243.
8. Zhao, Y.; Lu, X.; Wan, F.; et al. Disruption of Circadian Rhythms by Shift Work Exacerbates Reperfusion Injury in Myocardial Infarction. *J. Am. Coll. Cardiol.* **2022**, *79*, 2097–2115.
9. Boivin, D.B.; Boudreau, P.; Kosmadopoulos, A. Disturbance of the Circadian System in Shift Work and Its Health Impact. *J. Biol. Rhythm.* **2022**, *37*, 3–28.
10. Ha, M.; Park, J. Shiftwork and metabolic risk factors of cardiovascular disease. *J. Occup. Health* **2005**, *47*, 89–95.
11. Allada, R.; Bass, J. Circadian Mechanisms in Medicine. *Engl. J. Med.* **2021**, *384*, 550–561.
12. Flo, E.; Bjorvatn, B.; Folkard, S.; et al. A reliability and validity study of the Bergen Shift Work Sleep Questionnaire in nurses working three-shift rotations. *Chronobiol. Int.* **2012**, *29*, 937–946.
13. Furlan, R.; Barbic, F.; Piazza, S.; et al. Modifications of cardiac autonomic profile associated with a shift schedule of work. *Circulation* **2000**, *102*, 1912–1916.

14. Shiffer, D.; Minonzio, M.; Dipaola, F.; et al. Effects of Clockwise and Counterclockwise Job Shift Work Rotation on Sleep and Work-Life Balance on Hospital Nurses. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2308.
15. Gomes, S.; Ramalhete, C.; Ferreira, I.; et al. Sleep Patterns, Eating Behavior and the Risk of Noncommunicable Diseases. *Nutrients* **2023**, *15*, 2462.
16. Szewczyk-Golec, K.; Woźniak, A.; Reiter, R.J. Inter-relationships of the chronobiotic, melatonin, with leptin and adiponectin: Implications for obesity. *J. Pineal Res.* **2015**, *59*, 277–291.
17. Russo, B.; Menduni, M.; Borboni, P.; et al. Autonomic Nervous System in Obesity and Insulin-Resistance-The Complex Interplay between Leptin and Central Nervous System. *Int. J. Mol. Sci.* **2021**, *22*, 5187.
18. Qian, J.; Morris, C.J.; Caputo, R.; et al. Circadian misalignment increases 24-hour acylated ghrelin in chronic shift workers: A randomized crossover trial. *Obesity* **2023**, *31*, 2235–2239.
19. D'Agostino Sr, R.B.; Vasan, R.S.; Pencina, M.J.; et al. General cardiovascular risk profile for use in primary care: The Framingham Heart Study. *Circulation* **2008**, *117*, 743–753.
20. Buijs, R.M.; Kreier, F. The metabolic syndrome: A brain disease? *J. Neuroendocrinol.* **2006**, *18*, 715–716.
21. Iavicoli, I.; Spatari, G.; Chosewood, L.C.; et al. Occupational Medicine and Total Worker Health(R): From preventing health and safety risks in the workplace to promoting health for the total well-being of the worker. *La Med. Del Lav.* **2022**, *113*, e2022054.
22. Fonarow, G.C.; Calitz, C.; Arena, R.; et al. Workplace wellness recognition for optimizing workplace health: A presidential advisory from the American Heart Association. *Circulation* **2015**, *131*, e480– e497.
23. Phoi, Y.Y.; Dorrian, J.; Rogers, M.; et al. Chronotype, temporal patterns of eating and diet composition on work and work-free days. *Chronobiol. Int.* **2024**, *41*, 1556–1565.
24. Saggi, M.K.; Phillips, C.L.; Comas, M.; et al. Does daily energy and macronutrient intake differ between work and non-workdays in shift workers? A mixed methods study. *Chronobiol. Int.* **2023**, *40*, 1039–1048.
25. Kollias, A.; Foukarakis, E.; Karakousis, K.; et al. Implementation of the 2018 ESC/ESH Guidelines for the management of hypertension in primary care: The HYPEDIA study. *J. Hum. Hypertens.* **2023**, *37*, 449–454.
26. Abramson, J.H.; Slome, C.; Kosovsky, C. Food frequency interview as an epidemiological tool. *Am. J. Public Health Nations Health* **1963**, *53*, 1093–1101.
27. Arie, S. WHO calls for more action to protect children from online junk food advertising. *BMJ* **2019**, *364*, l1221.
28. WHO. Healthy Diet. Available online: https://iris.who.int/bitstream/handle/10665/325828/EMROPUB_2019_en_23536.pdf (accessed on 12 June 2025).
29. WHO. *Diet, Nutrition and the Prevention of Chronic Diseases: Report of A Joint WHO/FAO Expert Consultation*; WHO: Geneva, Switzerland, 2002.
30. Lotti, S.; Moretton, M.; Bulgari, M.; et al. Association between shift work and eating behaviours, sleep quality, and mental health among Italian workers. *Eur. J. Nutr.* **2025**, *64*, 97.
31. Clark, A.B.; Coates, A.M.; Davidson, Z.E.; et al. Dietary Patterns under the Influence of Rotational Shift Work Schedules: A Systematic Review and Meta-Analysis. *Adv. Nutr.* **2023**, *14*, 295–316.
32. Liu, Q.; Shi, J.; Duan, P.; et al. Is shift work associated with a higher risk of overweight or obesity? A systematic review of observational studies with meta-analysis. *Int. J. Epidemiol.* **2018**, *47*, 1956–1971.
33. Rivera, A.S.; Akanbi, M.; O'Dwyer, L.C.; et al. Shift work and long work hours and their association with chronic health conditions: A systematic review of systematic reviews with meta-analyses. *PLoS ONE* **2020**, *15*, e0231037.
34. Hunger, B.; Seibt, R. Psychosocial Work Stress and Health Risks—A Cross-Sectional Study of Shift Workers from the Hotel and Catering Industry and the Food Industry. *Front. Public Health* **2022**, *10*, 849310.
35. Xu, M.; Yin, X.; Gong, Y. Lifestyle Factors in the Association of Shift Work and Depression and Anxiety. *JAMA Netw. Open* **2023**, *6*, e2328798.
36. Roskoden, F.C.; Krüger, J.; Vogt, L.J.; et al. Physical Activity, Energy Expenditure, Nutritional Habits, Quality of Sleep and Stress Levels in Shift-Working Health Care Personnel. *PLoS ONE* **2017**, *12*, e016998343.
37. Tobaldini, E.; Fiorelli, E.M.; Solbiati, M.; et al. Short sleep duration and cardiometabolic risk: From pathophysiology to clinical evidence. *Nat. Rev. Cardiol.* **2019**, *16*, 213–224.
38. Guarino, D.; Nannipieri, M.; Iervasi, G.; et al. The Role of the Autonomic Nervous System in the Pathophysiology of Obesity. *Front. Physiol.* **2017**, *8*, 665.
39. Lennernäs, M.; Åkerstedt, T.; Hambraeus, L. Nocturnal eating and serum cholesterol of three-shift workers. *Scand. J. Work. Environ. Health* **1994**, *20*, 401–406.
40. Zitting, K.M.; Vetrivelan, R.; Yuan, R.K.; et al. Chronic circadian disruption on a high-fat diet impairs glucose tolerance. *Metabolism* **2022**, *130*, 155158.
41. Eriksson, A.K.; Van Den Donk, M.; Hilding, A.; et al. Work stress, sense of coherence, and risk of type 2 diabetes in a prospective study of middle-aged Swedish men and women. *Diabetes Care* **2013**, *36*, 2683–2689.
42. Broussard, J.L.; Klein, S. Insufficient sleep and obesity: Cause or consequence. *Obesity* **2022**, *30*, 1914–1916.

43. Wu, Q.J.; Sun, H.; Wen, Z.Y.; et al. Shift work and health outcomes: An umbrella review of systematic reviews and meta-analyses of epidemiological studies. *J. Clin. Sleep Med.* **2022**, *18*, 653–662.
44. Gopalakrishnan, S.; Kannan, N.N. Only time will tell: The interplay between circadian clock and metabolism. *Chronobiol. Int.* **2021**, *38*, 149–167.
45. Rudic, R.D.; McNamara, P.; Curtis, A.-M.; et al. BMAL1 and CLOCK, two essential components of the circadian clock, are involved in glucose homeostasis. *PLoS Biol.* **2004**, *2*, e377.
46. Johnston, J.D. Physiological links between circadian rhythms, metabolism and nutrition. *Exp. Physiol.* **2014**, *99*, 1133–1137.
47. Kim, T.W.; Jeong, J.H.; Hong, S.C. The impact of sleep and circadian disturbance on hormones and metabolism. *Int. J. Endocrinol.* **2015**, *2015*, 591729.
48. Catalano, F.; De Vito, F.; Cassano, V.; et al. Circadian Clock Desynchronization and Insulin Resistance. *Int. J. Environ. Res. Public Health* **2022**, *20*, 29.
49. Stenvers, D.J.; Scheer FA, J.L.; Schrauwen, P.; et al. Circadian clocks and insulin resistance. *Nat. Rev. Endocrinol.* **2019**, *15*, 75–89.
50. Lewis, P.; Oster, H.; Korf, H.W.; et al. Food as a circadian time cue—Evidence from human studies. *Nat. Rev. Endocrinol.* **2020**, *16*, 213–223.
51. Wehrens SM, T.; Christou, S.; Isherwood, C.; et al. Meal Timing Regulates the Human Circadian System. *Curr. Biol.* **2017**, *27*, 1768–1775.e3.
52. Pan, A.; Schernhammer, E.S.; Sun, Q.; et al. Rotating night shift work and risk of type 2 diabetes: Two prospective cohort studies in women. *PLoS Med.* **2011**, *8*, e1001141.
53. Kecklund, G.; Axelsson, J. Health consequences of shift work and insufficient sleep. *BMJ* **2016**, *355*, i5210.
54. Holtermann, A.; Krause, N.; Van Der Beek, A.J.; et al. The physical activity paradox: Six reasons why occupational physical activity (OPA) does not confer the cardiovascular health benefits that leisure time physical activity does. *Br. J. Sports Med.* **2018**, *52*, 149–150.
55. Hallman, D.M.; Mathiassen, S.E.; Gupta, N.; et al. Differences between work and leisure in temporal patterns of objectively measured physical activity among blue-collar workers. *BMC Public Health* **2015**, *15*, 976.
56. Quintiliani, L.; Poulsen, S.; Sorensen, G. Healthy Eating Strategies in the Workplace. *Int. J. Workplace Health Manag.* **2010**, *3*, 182–196.
57. Leso, V.; Carugno, M.; Carrer, P.; et al. The Total Worker Health(R) (TWH) approach: A systematic review of its application in different occupational settings. *BMC Public Health* **2024**, *24*, 2037.
58. Rongen, A.; Robroek, S.J.W.; van Lenthe, F.J.; et al. Workplace health promotion: A meta-analysis of effectiveness. *Am. J. Prev. Med.* **2013**, *44*, 406–415.
59. Veronesi, G.; Borchini, R.; Landsbergis, P.; et al. Cardiovascular disease prevention at the workplace: Assessing the prognostic value of lifestyle risk factors and job-related conditions. *Int. J. Public Health* **2018**, *63*, 723–732.
60. Ferrario, M.M.; Veronesi, G.; Bertù, L.; et al. Job strain and the incidence of coronary heart diseases: Does the association differ among occupational classes? A contribution from a pooled analysis of Northern Italian cohorts. *BMJ Open* **2017**, *7*, e014119.
61. Chellappa, S.L.; Gao, L.; Qian, J.; et al. Daytime eating during simulated night work mitigates changes in cardiovascular risk factors: Secondary analyses of a randomized controlled trial. *Nat. Commun.* **2025**, *16*, 3186.
62. Magnavita, N.; Di Prinzio, R.R.; Arnesano, G.; et al. Association of Occupational Distress and Low Sleep Quality with Syncope, Presyncope, and Falls in Workers. *Int. J. Environ. Res. Public Health* **2021**, *18*, 12283.