The effect of shift work on eating habits: a systematic review
by Souza RV, Sarmento RA, de Almeida JC, Canuto R

This is the first systematic review examined the association between shift work and eating habits. The results suggest that dietary quality can be altered by shift work. Shift workers showed changes in meal pattern, skipping more meals and consuming more food at unconventional times. They also seem to consume foods enriched with saturated fats and lower amount of fibers.

Affiliation: Federal University of Rio Grande do Sul, Medicinal School, Department of Nutrition. Rua Ramiro Barcelos, 2400-Rio Branco; 90035003 - Porto Alegre, RS - Brazil. raquelcanuto@gmail.com

Refers to the following texts of the Journal: 1994;20(6):401-406 2016;42(6):459-468

Key terms: diet; eating habit; food habit; food pattern; meal pattern; metabolism; night eating; night work; nocturnal eating; nutrition; shift work; shift worker; sleep disorder; systematic review

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/30088659

Additional material
Please note that there is additional material available belonging to this article on the Scandinavian Journal of Work, Environment & Health -website.
The effect of shift work on eating habits: a systematic review

by Renata Vieira Souza, MSc,1 Roberta Aguiar Sarmento, PhD,1 Jussara Carnevale de Almeida, PhD,1,3 Raquel Canuto, PhD2,3

Souza RV, Sarmento RA, de Almeida JC, Canuto R. The effect of shift work on eating habits: a systematic review. Scand J Work Environ Health. 2019;45(1):7–21. doi:10.5271/sjweh.3759

Objective This systematic review aimed to evaluate the association between shift work and eating habits.

Methods The protocol was registered in PROSPERO (number 42015024680). PubMed, EMBASE, Scopus, and Web of Science were searched for published reports. Of 2432 identified articles, 33 observational studies met the inclusion criteria. Their methodological approaches were assessed using the Newcastle-Ottawa Scale. Data were extracted using a standardized form. Studies were considered to have a low or a high risk of bias according to a percentage score of quality.

Results The majority of the studies presented a quality score of <70% and a high risk of bias for comparability, sample selection and non-respondents. Shift workers show changes in meal patterns, skipping more meals and consuming more food at unconventional times. They also show higher consumption of unhealthy foods, such as saturated fats and soft drinks.

Conclusions This review suggests that shift work can affect the quality of workers’ diets, but new studies, especially longitudinal studies, which examine the time of exposure to shift work, the duration of the workday and sleep patterns, are necessary to confirm this association.

Key terms diet; food habit; food pattern; meal pattern; metabolism; night eating; nocturnal eating; night work; nutrition; shift worker; sleep disorder.

Shift work is characterized by schedules that differ from conventional working hours (for example, work hours in Brazil are commonly between 08:00–09:00 and 17:00–18:00 hours) (1, 2). Night work and work that occurs continuously for 24 hours with rotating shifts (2, 3) also fall within this definition of shift work. During the last few decades, the proportion of shift workers has been increasing (2, 4). This work system has been described as an important risk factor in the etiology of metabolic disorders and chronic diseases (1, 5–10).

The causal mechanisms of this association are not fully elucidated, but observational studies indicate that changes in work schedules result in physiological and behavioral changes in shift workers (11–14). These workers suffer from a disruption of the circadian rhythm and therefore experience hormonal alterations due to being awake at the time biologically reserved for sleep (11, 15, 16). In addition, in shift work, the reorganization of nighttime and daytime activities involves changes in lifestyle, including eating habits (7, 14, 17, 18).

Working in shifts can affect eating habits in a variety of aspects. Epidemiological studies have shown differences in relation to the consumption of calories and macronutrients and the quality of the food eaten by shift workers (7, 11, 17, 19). Changes in meal patterns, ie, meal frequency, types of meals and times for meals (20), have also already been previously associated with changes in work schedules and/or sleep deprivation (17, 21, 22).

Systematization of the knowledge about the influence of shift work on eating habits is critical in understanding the relationship between work shifts and metabolic disorders and chronic diseases. In this sense, three published review studies on this topic were found. One narrative review described dietary characteristics among shift

1 Endocrinology Division, Porto Alegre University Hospital, Federal University of Rio Grande do Sul, Porto Alegre, Brazil.
2 Department of Nutrition, Medicinal School, Federal University of Rio Grande do Sul, Porto Alegre, Brazil.
3 Food and Nutrition Research Center- Hospital de Clinicas de Porto Alegre / Federal University of Rio Grande do Sul, Porto Alegre, Brazil.

Correspondence to: Raquel Canuto, Federal University of Rio Grande do Sul, Medicinal School, Department of Nutrition. Rua Ramiro Barcelos, 2400-Rio Branco; 90035003 - Porto Alegre, RS – Brazil. [E-mail: raquelcanuto@gmail.com]
workers but did not compare dietary characteristics with those of non-shift worker controls (23). A systematic review investigated dietary habits in conjunction with the nutritional status of workers (5). In addition, a meta-analysis study focused only on energy intake assessment (13). Therefore, it is necessary to carry out review studies with a high-quality systematic approach that investigate the association between the timing of work shifts and dietary habits, considering eating habits in a broad way, including quantitative and qualitative assessments of diet, as well as the meal patterns of workers.

Thus, the aim of this study was to perform a systematic review of evidence of the association between shift work and eating habits. We hypothesized that shift workers have irregular eating times, skip main meals and have a higher consumption of snack meals and foods rich in sugars and fats than daytime workers.

Methods

A systematic literature review was carried out to summarize the results of observational studies that evaluated the impact of different work shifts on the eating habits of individuals. The protocol of this review was done in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (24) and the Meta-Analysis Of Observational Studies in Epidemiology Check List (MOOSE) (25) and was registered in PROSPERO (number 42015024680). Because it was a literature review, no ethics committee approval was required. The PICO (Population, Intervention, Control and Outcome) strategy was used to construct the research question (table 1). The articles were selected according to the following inclusion criteria: (i) have as an outcome the evaluation of eating habits (consumption of calories, nutrients, food groups or meal patterns); (ii) compare individuals in different shifts (rotating or night vs. regular or day shift workers); (iii) be an original article; and (iv) have full text available for reading.

The searches were conducted in PubMed, Scopus, EMBASE, and Web of Science from February to June 2017. Articles published by September 2017 were included. The descriptors are defined according to Medical Subject Headings (MeSH) for searches performed in PubMed and according to EMBASE subject headings (Emtree) for searches performed in EMBASE. The research strategy used in PubMed is presented in table 2. Additional studies were identified in the references of articles selected.

Two investigators independently performed the initial selection of articles by reading all of the titles and abstracts. Endnote X7 software was used to manage the selection of articles. In a second step, the two reviewers performed the complete reading of the articles according to the inclusion criteria. In case of divergence between the two researchers, a third researcher was consulted for a final decision. Afterwards, the data from the studies that met the criteria were extracted, and the following information was considered: sample characteristics, losses (%), exposure classification (shift work), assessment tool of eating habits, classification of food consumption and main results. Authors were contacted when the information was not available in its entirety (26–28).

The Newcastle-Ottawa Scale (NOS) instrument was used to assess the quality of studies (29). In cross-sectional studies, we used an adaptation to specific criteria for sampling, non-response rate and statistical tests employed, as proposed by Herzog et al (30). The instruments include items divided in three areas: selection, comparability and outcome. All items received a maximum score of 1 when the evaluated criteria were met and 0 if they were not identified. In cross-sectional studies, a maximum of 2 points could be attributed when the best criterion was identified in the questions that assess the definition of exposure and control for confounding factors (comparability) and outcome measurement. Two researchers carried out all evaluations independently. In case of disagreement, the third researcher was consulted.

The percentage score of quality evaluation was set as follows: the total score of each study divided by the maximum score applied to the checklist (10 for cross-sectional studies and 9 longitudinal studies) and finally multiplied by 100. In a second stage, a general evalu-
tion of the quality of the articles was performed for each item evaluated in the instrument. Studies that received 1–2 points for each domain were considered to have a low risk of bias, and those that received 0 points were considered to have a high risk of bias.

Results

Study selection

The results of the article selection procedure are presented in figure S1 (www.sjweh.fi/show_abstract.php?abstract_id=3759). The initial search resulted in 2660 articles. After the exclusion of duplicates, 2432 were selected for titles and abstracts. Under consensus of the two reviewers, 118 papers were selected for complete reading and 92 were excluded as they did not meet the inclusion criteria in relation to the outcome (N=48) and group comparison (N=43). Ultimately, 27 studies were included, and with the addition of 6 articles retrieved from their bibliographic references, 33 studies were included in this review. There was agreement between the reviewers, with kappa=0.835.

Study characteristics

Table 3 presents the characteristics of the articles. Of the total 33 studies included, 10 included only female subjects (22, 31–39), 13 studies included only males (6, 7, 11, 21, 40–48) and 10 studies included both sexes (17, 19, 28, 49–55). Workers from different sectors were evaluated as follows: workers in industries and plants (N=10) (6, 11, 17, 31, 39, 41–44, 46), hospitals (N=10) (28, 32–38, 49, 51), transportation company workers (N=4) (7, 40, 47, 50), and the general population (N=9) (19–22, 28, 45, 48, 52–55). The sample sizes ranged from 22 (42) to 107615 (32) subjects were aged 20–65 years old. We selected two retrospective cohort studies (22, 32), a case–control study (34), and 30 cross-sectional studies (6, 7, 11, 17, 19, 21, 28, 31, 33, 35, 36, 38–56). In the individual assessment of the quality of studies, only 9 studies showed scores >70% (17, 19, 22, 32, 36, 40, 50, 54, 55).

Quality assessment

Figure S2 (www.sjweh.fi/show_abstract.php?abstract_id=3759) shows the results of quality evaluation according to each criterion. Most studies (75%) presented a high risk of bias in the comparisons between the exposed/non-exposed groups and did not present analysis adjusted for confounding factors. Over 60% of studies did not consider the description of non-respondents. Nevertheless, in relation to the selection, more than half of the studies did not report a power calculation for their sample size.

Quantitative and qualitative analysis

Considering the different forms of assessment of dietary habits, the results of the studies are divided into the consumption of calories and nutrients (table 4); food groups and food patterns (table 5); or both, when studies evaluated quantitative and qualitative variables (table 6).

Table 4 shows studies (11, 38, 42, 44, 46, 47) that only evaluated the intake of calories and nutrients, using 24-hour dietary recall (24HR) (42) and dietary records (11, 38, 42, 46, 47). On the other hand, table 5 shows studies that evaluated the intake of food groups (17, 40, 50, 53) and eating pattern scores (5, 17, 31, 34, 35, 41, 54–55) through food frequency questionnaires (FFQ) (5, 17, 40, 51, 53, 55), questionnaires about meals and food patterns (31, 34, 35, 41, 56), and 24HR (54). Of these, 12 were cross-sectional (6, 17, 31, 34, 35, 37, 40, 41, 50, 53–55), and 1 was a case-control study (34). Regarding the quality of the studies, only 5 presented scores >70% (17, 40, 50, 54, 55). The 15 studies that evaluated the aspects related to both the intake of calories and nutrients and the consumption of food groups and eating patterns are described in table 6. The dietary intake assessment tools range from FFQ (6, 19, 22, 28, 32, 36, 43, 51, 52), 24HR (21, 45, 48), and dietary records (21, 39, 45). There were 2 longitudinal studies (22, 32), and 4 had quality scores >70% (19, 22, 32, 36).

Quantitative analysis

Energy intake was evaluated in 16 studies (11, 19, 22, 32, 36, 38, 39, 42–48, 52, 53) and among these studies, 13 evaluated macronutrients (11, 19, 22, 32, 38, 39, 42–48) (tables 4 and 6). When compared to daytime workers, 5 studies observed a higher intake of total calories among the evening shift workers (11, 22, 38) and among workers with rotating shifts (19, 36), although 2 other studies show lower caloric consumption among these workers (39, 42).

Differences in macronutrient intake were found in 9 studies, when shift workers or rotating shift workers were compared to daytime/fixed workers. (11, 19, 39, 42, 43, 45, 46, 52). If, on the one hand, 3 studies observed a lower protein intake among night workers (39) and workers with rotating shifts (19, 42), on the other hand, 1 study found increased protein intake by night workers (11). In 3 studies, lower carbohydrate intake was found for night workers (11, 39, 42), and 2 found a greater consumption of carbohydrates (38, 45). Lower consumption of fiber among night shift workers (42) and rotating shift workers (43) were found in 2 studies. Regarding lipids, shift workers had a higher
Table 3. Summary of population, design characteristics and methodological approaches of the studies sorted (N=33). Check list The New Castle-Ottawa Scale (27) and its version adapted to cross-sectional studies (28). [IQR=interquartile range; NHS=Nurses Health Study; NR=not reported.]

| Author-Year          | Year – data collection | Population                          | N (Loss %) | Age (years)* | Score* |
|----------------------|------------------------|-------------------------------------|------------|--------------|--------|
|                      |                        |                                     |            | Years        | Mean  | SD   | Median | IQR  |
| Cohort               |                        |                                     |            |              |        |      |        |      |
| Vimalananda VG et al, 2015 (22) | 1995–2005               | African-American women (readers / magazine subscribers) | 28,041     | 21–69        | -      | -    |        | 88.9 |
| Pan A et al, 2011 (32) | 1988–2000 (NHS I) and 1989–2007 (NHS II) | Women NHS I and NHS II | 69,269 (NHS I) 107,615 (NHS II) | 53.9 (NHS I) 34.3 (NHS II) | - | - | 77.8 |
| Case-control         |                        |                                     |            |              |        |      |        |      |
| Zverev Y 2005 (34)   | 2005                   | Women malawi- nurses                | 24         | NR           | 55.6   |
| Freitas E et al, 2015 (17) | 2010                   | Brazilian men and women – slaughter-house workers | 1206       | 30.5         | 9.7    | 88.9 |
| Husegge G et al, 2016 (19) | 1993–2014              | Dutch men and women – population-based | 7,856      | 42.7         | 10.1   | 88.9 |
| Chen C et al, 2010 (40) | Jul-Aug / 2004         | Chinese men, bus drivers            | 184        | 42.2         | 0.6    | 77.8 |
| Haupt CM et al, 2008 (55) | 1997–2001              | Men and women- German population    | 2,510      | 61.5         | 10.1   | 77.8 |
| Hemiö K et al, 2015 (50) | 2006–2009              | Men and women – aviation company in Finland | 1,478      | NR           | 77.8   |
| Wirth M et al, 2014 (54) | 2005–2010              | American Men and women – population-based | 7,643      | 20–80        | -      | 77.8 |
| Cody A et al, 2015 (36) | 1989–2009              | American women – nurses             | 54,724     | 25–42        | -      | 77.7 |
| Kim M et al, 2013 (35) | 2011                   | Korean women, nurses                | 9,989      | 33.2         | -      | 66.7 |
| Li Y et al, 2011 (53)  | 1987–1990              | Japanese men and women – population-based | 6,712      | 20–59        | -      | 66.7 |
| Barbadoro P et al, 2013 (6) | 2008                   | Italian men – steel workers         | 339        | 42.1         | 12.2   | 66.7 |
| Lin YC et al, 2009 (31) | 2002–2007              | Chinese women- electronics factory  | 387        | 32.8         | 7.9    | 66.7 |
| Lin YC et al, 2014 (41) | 2005–2007              | Chinese men – electronics factory   | 1,196      | 32.5         | 6.0    | 66.7 |
| Zhao I et al, 2011 (37) | 2006–2008              | Women, Australian, New Zealand and British, nurses | 2,494      | 42.8         | 9.9    | 66.7 |
| Lennernas M et al, 1994 (42) | 1994                   | Swedish men – steel workers         | 22         | 35.7         | 7.2    | 66.7 |
| Lasfargues G et al, 1996 (52) | 1996                   | French men and women – population-based | 2,400      | 30–29        | -      | 66.7 |
| Balieiro LC et al, 2014 (7) | April-Dec / 2012      | Brazilian men, bus drivers          | 150        | 46.7         | 9.9    | 56.6 |
| Rodriguez M et al, 2009 (28) | 2000–2001              | Spanish men and women, hospital workers | 417        | 24–65        | -      | 56.6 |
| Morikawa Y et al, 2008 (43) | 2003                   | Japanese men- metal company         | 2,254      | 20–59        | -      | 56.6 |
| Monique R et al, 1992 (44) | 1988–1989              | French men – plant operators        | 63         | 32.4         | 31.9   | 55.6 |
| Han K et al, 2016 (33) | 2012                   | Korean women, nurses                | 340        | 22–40        | -      | 55.6 |
| Assis MA et al, 2003 (21) | 1999                   | Brazilian men, garbage collectors   | 66         | 20–44        | -      | 44.4 |
| Assis M et al, 2003 (45) | 1999                   | Brazilian men, garbage collectors   | 66         | 20–44        | -      | 44.4 |
| Esquirol Y et al, 2009 (46) | 2001–2002              | French men – chemical plant workers | 198        | 39–60        | -      | 44.4 |
| Cardozo D et al, 2013 (38) | 2012                   | Women Brazilian hospital cleaning-service | 24         | 20–40        | -      | 44.4 |
| Crispim CA et al, 2011 (11) | NR                    | Brazilian men, steel workers        | 22         | 26.7         | 2.1    | 33.3 |
| Sampedro E et al, 2010 (51) | 2007                   | Spanish men and women, hospital workers | 311        | -            | 39     | 8     | 33.3 |
| Pasqua IC et al, 2004 (47) | NR                    | Brazilian men – railway transportation | 28         | 32.8         | 5.3    | 33.3 |
| Sudo N et al, 2001 (39) | 1998                   | Japanese women – computer factory   | 137        | 25–31        | 5.3    | 33.3 |
| Waterhouse J et al, 2003 (49) | NR                    | British men and women – nurses      | 93         | 25–31        | 5.3    | 33.3 |
| Bonell EK et al, 2017 (48) | NR                    | Australian men – firefighters       | 41         | -            | 30–52  | 33.3 |

*Age (years) expressed in mean ± standard deviation, age (up minimum) or median (interquartile range).

1. Assigned from the quality analysis (%).
2. Day shift; *Shift work; **Night shift; †Morning shift; ††Afternoon shift; †††Night shift I; †††Night shift II.
intake of total lipids in 2 studies (11, 38) and a lower consumption of total lipids in 2 others (39, 42). Five studies evaluated the type of fat consumed (19, 42, 43, 45, 52), three studies (43, 46, 52) observed a higher consumption of saturated fat among rotating shift workers, and one study (42) observed lower consumption of saturated fat among night workers.

The evaluation of micronutrient intake was performed in only 3 studies (39, 42, 43), of which 2 found a lower consumption of calcium in rotating shift (43) or overnight workers (39). Lower potassium intake was also observed among night shift workers, and a lower intake of vitamins A and B1 and iron (39) was observed in rotating shift workers aged 20–29 years (43).

Qualitative analysis

An evaluation of food groups was performed in 15 studies (7, 19–22, 28, 32, 33, 36, 40, 45, 50–53) (tables 5 and 6), and 10 of them found associations (7, 19, 22, 28, 33, 43, 45, 50, 52, 53). In some studies, rotating shift workers or night shift workers presented a higher consumption of starch foods (19, 28), breads and cereals (52), fruits and vegetables (7, 50, 53), meats and animal foods (6, 19, 28), sugar and candies (45, 48), soft drinks (21, 22, 28, 45, 52), oils and fats (6, 21), and alcoholic beverages (45, 53) than daytime workers. On the other hand, in other studies, these workers had a lower consumption of starch foods, breads and cereals (21, 45, 50), fruits and vegetables (7, 21, 33 45), meats and animal foods (21, 45), sugars, sweets and/or desserts (19, 42), oils and fats (43), and alcoholic beverages (22, 44).

Food habits were evaluated in 9 studies through diet quality scores or dietary patterns (6, 17, 19, 22, 32, 36, 37, 54, 55). In a study by Barbadoro et al (6), working in a rotating shift system was inversely associated with an increased cardiovascular risk score, whereas in 2 other studies, rotating shift work was positively associated

Table 4. Summary of the main results of studies that evaluated nutrient intake and calories (N= 6). Data presented as mean ± standard deviation, [DR= dietary record; PTN= protein; CHO= carbohydrates; LIP= lipids; NS= not significant; 24HR= 24-hour dietary recall; BK= breakfast; S1= snack 1; L= lunch; S2= snack 2; D= dinner; S3= snack 3.]

| Study | Work shift | Dietary assessment | Information assessed eating habits | Significant results |
|-------|------------|--------------------|-----------------------------------|---------------------|
| Crispim CA et al, 2011 (11) | Morning (06:00–14:00) Day shift (08:00–17:00) Night (22:00–06:00) | DR – 7 days | Energy intake (kcal / day) and macronutrients (EI%) | Morning EI = 2649 ± 366,636 kcal PTN = 20,2 ± 1,1% CHO = 45,3 ± 1,6% LIP = 34,4 ± 1,9% |
| Esquirol Y et al, 2009 (46) | Fixed (beginning at 08:00) Rotating (beginning at 05:00, 13:00 or 21:00) Duration of journey: 8 hours | DR – Fixed: 3 working days Rotating: 4 (1 day 1 every on each shift +1 day off) | Energy intake (kcal / day), consumption of macronutrients (g / day) and energy contribution percentage meals (% EI): Breakfast (BK) Snack 1 (S1) Lunch (L) Snack 2 (S2) Dinner (D) Snack 3 (S3) | Fixed shift Frequency of meals / day: 0,1 ± 0,09 Saturated fatty acids (g / day): 23,2 ± 0,96 Rotating shift |
| Pasqua IC et al, 2004 (47) | Morning (07:00–15:30) Afternoon (15:15–23:15) Night (23:00–07:30) | DR – 2 working days + 1 off | Energy intake (kcal / day) and macronutrients (g / day) | NS |
| Monique R et al, 1992 (44) | Day: administrative work Rotating: alternate shifts every 2 days (beginning at 06:00, 14:00 and 22:00) | DR – 3 days | Energy intake (kcal / day), macronutrients (g / day), ethanol (g / day), sugar (g / day) and coffee (ml / day) | Day shift Ethanol (g/day): 15,64 (0.97–252) Rotating shift |
| Cardozo DS et al, 2013 (38) | Day: “business hours” Night (19:00–07:00) | DR – 3 days | Energy intake (kcal / day) and macronutrients (g / day) | Day shift Calories (kcal): 317,83 ± 1623 Macronutrients (g / day): CHO: 217,74 ± 64,64 LIP: 60,39 ± 12,47 Rotating shift |
| Lennernas M et al, 1984 (42) | Even individual working different shifts (05:30–14:00) Afternoon (14:00–22:30) Night (22:30–05:30) | 24HR 4 (1 hour at every shift + 1) | Energy intake and macronutrients during each work shift over 24 hours (%) | Morning Kcal: 47, ± 17% PTN (g): 47 ± 16% CHO (g): 47 ± 14% Sucrose (g): 43 ± 25% Fibers (g): 46 ± 20% LIP (g) 46 ± 21% Saturated f. acids (g): 46 ± 21% | Afternoon Night |

* Statistical significant difference between night and morning workers.

ab Statistical significant difference between night and day workers.

Scand J Work Environ Health 2019, vol 45, no 1
with unhealthy eating patterns (22) and inflammatory potential (54), characterized by the consumption of fatty and fried foods (tables 5 and 6).

Finally, 12 studies investigated meal patterns, comparing shift workers or rotating shift workers to daytime/ fixed workers. The number of meals consumed was evaluated in 6 studies (17, 21, 33, 35, 45, 49) and were higher among night shift workers in 2 studies (17, 21). Of the 10 studies that compared the types of meals (17, 21, 33, 35, 41, 45, 46, 49, 52, 53), 7 had the following associations: night and rotating shift workers skip more meals at lunch and breakfast in the 4 studies that evaluated this behavior (17, 33, 35, 52). Of the 6 studies that evaluated the time of food intake, 5 (17, 21, 33, 41, 46) showed higher consumption of food at night among night shift and rotating shift workers. Nevertheless, at least 1 study showed higher consumption of breakfast at inappropriate times for night workers and dinner for daytime workers (17).

Summary of main results

A summary of the associations in these studies is described in table 7. When the associations found in each study between work shift and eating habits are analyzed together, it is possible to conclude that shift workers have a higher consumption of saturated fats and soft drinks than daytime workers. Likewise, shift workers skip more meals and have a higher meal intake at night. With regard to energy intake and micronutrient consumption, the results of the studies are varied, and most studies found no associations. Most studies that assessed scores and dietary patterns also found no associations.

Discussion

This systematic review included results from 33 observational studies (30 cross-sectional, 2 longitudinal, and 1 case-control) that investigated associations between shift work and eating habits. Thus, the evidence found should be evaluated in consideration of the limitations of cross-sectional study designs. The evidence found suggests that shift work (night and rotating) can lead to changes in workers’ eating habits when the pattern of meal consumption was evaluated. Aside from the skipped meals, the studies included in this review have shown that shift workers show differences in the distribution of food intake, with increased food consumption during the night among night shift workers than among rotating or daytime workers. In addition, there seems to be a trend toward greater consumption of foods rich in saturated fats and soft drinks among shift workers (22, 42, 43, 54). Studies of workers and the general population have shown that changes in the pattern of meals are an independent risk factor for weight gain (56), glucose intolerance, insulin resistance, dyslipidemia and obesity (57–59). Skipping breakfast is associated with excess weight and changes in metabolic markers, regardless of total caloric intake (60–62). In addition, the increased consumption of food and calories during the night has also been associated with metabolic changes and weight gain (62–65). Experimental studies have shown that animals fed during the period considered inactive have greater weight gain and increased body fat, regardless of the type of diet provided (66–68). In humans, increased food consumption in the later hours of the day was positively associated with overweight among healthy men and women (65, 69, 70). Additionally, individuals undergoing a weight loss program who eat at later hours show less weight loss than those who have the same diet but consume food earlier in day (59).

The causal pathway that links changes in eating patterns to metabolic disturbances can be explained by circadian rhythm disruption. The production of hormones and metabolic function is synchronized with the circadian rhythmicity system (36, 68–70). Experimental (25, 70) and epidemiological studies (60, 61, 64) show that healthy individuals with changes in biological patterns of sleep and wakefulness may have reduced production of leptin, increased ghrelin and increased insulin resistance. Thus, changes in the regulation of body temperature, digestion, energy metabolism and hormonal responses are experienced by individuals who eat during the rest period (63, 68, 70, 71).

Changes in the consumption of food groups and nutrients that make up an unhealthy food pattern were also identified among shift workers. An increased intake of saturated fats and soft drinks was identified in shift workers’ diets. Shift workers and permanent night workers – already exposed to chronobiological and hormonal changes as a result of their working hours – may present additional risk factors for the development of metabolic alterations due to the excessive consumption of these products, which contributes to excess weight, obesity and the development of non-transmittable chronic diseases (72). In addition, this finding suggests the recognition of eating habits as possible contributing risk factors for the development of chronic diseases. The occurrence of cardiovascular events has been positively associated with shift work. In a literature review and meta-analysis of observational studies, a higher risk of infarction and coronary events was found among workers performing shift work activities (73).

There is insufficient evidence of an association between the consumption of energy, protein, carbohydrates and micronutrients and shift work. These results reinforce the findings by Bonham et al (13) demonstrat-
### Table 5. Summary of the main results of studies that evaluated of food groups, meal and eating patterns (N= 12). [FFQ= food frequency questionnaire; 24HR = 24-hour dietary recall; NS= not significant; NSP= not specified; RYP= Rate Your Plate; IID= Inflammatory Index Diet.]

| Study                        | Work shift                                      | Dietary survey used          | Information assessed - eating habits | Significant results. Data are presented as mean ± SD mean (95% confidence interval) and percentage (%) |
|------------------------------|-------------------------------------------------|------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------|
| Chen et al, 2010 (40)        | Regular = non-rotating                           | FFQ                          | Food groups: alcohol, coffee, fruits and vegetables                                      | NS                                                                                               |
| Barbadoro et al, 2013 (35)   | Fixed = 07:00/08:00 – 16:00/17:00 Rotating = 2 days in each shift Morning = 06:00–14:00 Afternoon = 14:00–22:00 Night = 22:00–06:00 | FFQ = Rate Your Eating Pattern Assessment | RYP score: measures of food rich in cholesterol, saturated fats and fried foods Higher score = higher intake | Fixed shift: 37.7 ± 5.6 Rotating shift: 36.1 ± 5.8                                                                 |
| Haupt et al, 2008 (55)       | Fixed = NSP Rotating self-report = (yes or no)   | FFQ                          | Food score according to the recommendations of the German Society for Nutrition Higher score = more appropriate | NS                                                                                               |
| Kim et al, 2013 (55)         | Regular = NSP Shifts NSP = Working time in shifts: 1st tertile: 0.08–3 years 2nd tertile: 3.08–6.75 years 3rd tertile: 6.83–38 years | Meal pattern questionnaire   | Meal consumption = breakfast, lunch and dinner                                            |                                                                                                  |
| Li et al, 2011 (53)          | Day shift = NSP Rotation self-report = (yes or no) | FFQ                          | Frequency of food consumption: Vegetables: ≤1 time / day; ≥2 times / day Habitual consumption of alcoholic beverages (% and ethanol ml/day; Frequency of snacks intake (yes or no) | Day shift: Vegetables: ≤1 time / day: 54.24%; ≥2 times / day: 45.76% Snacks: No: 67.86%; Yes: 32.14% Alcoholic drinks: Unusual: 68.49%; Habitual: 31.51% % Ethanol (ml / day) ≤23 ml/day: 19.48% to 46 ml/day: 9.46%; ≥69 ml/from: 2.57% | Day shift: Snacks before bed: 35.5% Regular consumption of alcohol: 7.2% Shift work: 43.1%; 2.5%; 1.1% | Trichile - shifts: 1st: 43.2%; 2nd: 47.1%; 3rd: 38.4%; 4th: 2.9%; 5th: 2.0%; 6th: 3.1%; skip dinner: 1st: 1.2%; 2nd: 1.3%; 3rd: 0.8% |
| Lin et al, 2009 (31)         | Day shift = starts at 07:30 Rotating = 6 workdays during the day (start at 07:30), 3 of rest + 6 work at night (start at 19:30) and 3 days of rest. Different answers between shifts in 2002 and 2007 Rotary persistent = Same shift response in 2002 and 2007 | Meal pattern questionnaire   | Usual snacks consumption (> 3 days / week) before sleep and between meals                 | NS                                                                                               |
| Lin et al, 2014 (41)         | Day shift = starts at 07:30 Rotating = 6 workdays during the day (start at 07:30), 3 of rest + 6 work at night (start at 19:30) and 3 days of rest. Different answers between shifts in 2002 and 2007 Rotary persistent = Same shift response in 2002 and 2007 | Meal pattern questionnaire   | Usual snacks consumption (> 3 days / week) before sleep and between meals                  | Day shift: Snacks before bed: 35.5% Regular consumption of alcohol: 7.2% Shift work: 43.1%; 2.5%; 1.1% | Day shift: Snacks before bed: 42.8%; 10.4% Persistent Rotating shifts: 49.4%; 11.6% |
| Wirth et al, 2014 (54)       | Shifts (NSP) Subjects classified into day / regular; afternoon / evening; and any rotating shifts (combination of afternoon / evening shift and rotation shifts) | 24HR                         | Inflammatory index diet score IID >0: pro-inflammatory IID <0: anti-inflammatory     | Regular: IID: 0.86 (0.79–0.94) Afternoon / evening: 0.96 (0.80–1.13) Rotating: 1.07 (0.92–2.2) Any rotating shift: 1.01 (0.89–1.13) |
| Zhao I et al, 2011 (37)      | Hours NSP Day shift: Daytime work and fixed Rotating: includes 5 different shift scales: Continuous, only late afternoon, only night, morning and late afternoon and evening | Dietary quality questionnaire: Australian Recommended Food Score (ARFS) | Food score of 74 points Higher scores = better diet quality | NS                                                                                               |
Table 5. Continued

| Study                  | Work shift                                      | Dietary survey used                      | Information assessed - eating habits                                      | Significant results                      |
|------------------------|-------------------------------------------------|------------------------------------------|---------------------------------------------------------------------------|------------------------------------------|
| Zverev 2005 (54)       | Day shift = fixed shift without night work      | Meal pattern questionnaire               | Number of meals (main and snack) on working days and rest                  | Day shift: work days meals: 2.26 ± 0.59  |
|                        | Rotating = 5 working days from 07:00–17:00; 3 nights from 17:00–07:00 and 5 days off |                                          |                                                                           | Rotating shift: Day: 2.06 ± 0.68; Night = 1.12 ± 0.50; Day off = 2.44 ± 0.81 |
| Hemiö et al, 2015 (50) | Day shift = 06:00–18:00 Rotating "in flight" = pilots or flight attendants Non-flights shift work (NSP) | FFQ                                      | Consumption of food groups stratified by sex Vegetables ≥ serving/day (%) |                                                           |
|                        |                                                |                                          | Fruits ≥ serving/day (%) High-fat Milk (HFM) (dl/day) Bread/slices/day     |                                                           |
|                        |                                                |                                          | Oil/fat breads = yes or no (%) Cheese (slices/day) Sweetened beverages    |                                                           |
|                        |                                                |                                          | (dl/day) Alcoholic beverages (servings/week)                               |                                                           |

| Freitas et al, 2015 (17) | Day shift start at 06:00 Night: beginning at 18:00 Duration 8h | FFQ and meal intake questions | Number and type of meals eaten throughout the day (%) Meals in “inappropriate” times outside the following times: Breakfast 06:00–08:30 Lunch 11:00–14:00 Dinner 18:00–21:00 | Day shift: meals consumed (%) 3 meals/day: 28.1% Breakfast: 62.6% Dinner: 90.5% Night snack: 5.3% Inadequate hours: Breakfast: 5.8% Dinner: 74.2% Night shift: 36%; 60%; 18.4%; 96.7%; 40.2% Others=NS |

*a* Rotating shifts differ from regular and afternoon shifts.  
*b* Significant results only for male workers.  
*c* Significant results only for female workers.

Description of the sample population, as well as a lack of information on the number and characteristics of non-respondents, allow for selection bias.

Nevertheless, methods of assessing the outcome varied among studies. The choice of instrument to assess food consumption should be considered a predefined objective, for example, quantitative assessment of nutrient intake, assessment of the consumption of food or food groups, or evaluation of dietary patterns (75). In this case, studies included in this review presented collection methods adequate for their objectives. The quantitative evaluation of feeding was performed from dietary records of two to seven days or 24HR. On the other hand, the evaluation of food group consumption and dietary patterns was carried out using FFQ validated for the population studied. Except for one study (54), all included studies repeated applications (two or more) of dietary questions about the previous 24HR and dietary records, thus reducing the limitations of these methods to assess the individuals’ usual intake. The evaluation of the usual diet is important, since the effects of inadequate food intake can occur only after prolonged exposure to shift work.

However, it is known that the self-report of food...
| Study and Year | Work shift | Dietary survey used | Information assessed eating habits | Significant results – data presented as mean (± standard deviation); average (95% confidence interval); median (25%, 75%); median (interquartile range - IQR) and percent (%); |
|---------------|------------|---------------------|-----------------------------------|-------------------------------------------------------------|
| Assis et al, 2003 (9) | Morning: 07:00–13:00; Afternoon: 15:00–21:00; Night: 21:00–03:00 | 24HR 1 and DR 2 | Energy intake (kcal / day) and macronutrients (g / day); Energy intake (kcal / day) of the following food groups: fruits and vegetables (FV), starches, baked foods, animal protein, alcoholic beverages, fats and sweets Frequency of meals and snacks in the after dawn, morning, midday, afternoon and evening. | Morning CHO (g): 407.6±13.4 FV: 110±10.5 kcal Starches: 1234±35.1 kcal Animal protein: 1230±35.1 kcal Alcohol: 81±9.0 kcal Candy: 468±21.2 kcal Soda: 403±162 ml Energy intake (% EI) at different times of day (after 03:00, morning, afternoon and evening). NAR (% EI) at different times of day (after 03:00, morning, afternoon and evening). Energy intake (% EI). Energy intake per period: Overnight: 1±0.5% Morning: 28.0±2.0% Day shift Servings / day Meat and eggs: 2.0±0.7 Fruits: 0.7±0.9 Inadequate intake Vegetables: 92.7% Oils: 24.6% | Morning CHO (g): 499.9±21.1 Afternoon: 151±12.3 Night: 1207±34.7 |
| Assis et al, 2003 (21) | Morning: 07:00–13:00; Afternoon: 15:00–21:00; Night: 21:00–03:00 | 1 and IR24h 2DR | Relative contribution of foods in caloric intake Consumption of food groups according to tertiles of each food group and prevalence of inadequate intake according to the Adapted Food Pyramid | Morning Meat: 22.3 ± 1.7% Breads: 12.4 ± 1.2% Additional Fat: 5.5 ± 0.4% Soda: 4.7 ± 0.7% Fruits / Vegetables: 3.1 ± 0.5% Eating episodes/days: Total: 5.3 ± 0.2% EI Energy intake per period: Overnight: 1 ± 0.5% Morning: 28.0 ± 2.0% Day shift Servings / day Meat and eggs: 2.0 ± 0.7 Fruits: 0.7 ± 0.9 Inadequate intake Vegetables: 92.7% Oils: 24.6% | Night Shift: 503.4 ± 27.5 |
| Baleiro LC et al, 2014 (7) | Day shift (NSP); Night shift (NSP) | FFQ | Consumption of food groups (servings / day) and prevalence of inadequate intake according to the Adapted Food Pyramid | Morning Meat: 22.3 ± 1.7% Breads: 12.4 ± 1.2% Additional Fat: 5.5 ± 0.4% Soda: 4.7 ± 0.7% Fruits / Vegetables: 3.1 ± 0.5% Eating episodes/days: Total: 5.3 ± 0.2% EI Energy intake per period: Overnight: 1 ± 0.5% Morning: 28.0 ± 2.0% Day shift Servings / day Meat and eggs: 2.0 ± 0.7 Fruits: 0.7 ± 0.9 Inadequate intake Vegetables: 92.7% Oils: 24.6% | Night Shift: 503.4 ± 27.5 |
| Sampedro ED et al, 2010 (51) | Fixed = day without night Rotation = Includes rotating night shift Fixed = only morning, afternoon or evening Rotating = morning, afternoon and evening on a rotating basis | FFQ | Adequate intake according to the Spanish Society of Community Nutrition (2004) | NS | NS |
| Rodriguez M et al, 2005 (28) | Fixed = 08:30–17:45 Rotation = early morning (06:00–13:45) or afternoon / evening (13:40–22:25) | FFQ | High, medium and low intake distribution according to tertiles of each food group | Fixed shift vs. rotating shift RC (95%) Meats: Moderate: 1.95 (1.13–3.34) High: 1.44 (0.83–2.51) Eggs: Moderate: 0.96 (0.61–1.53) High: 1.74 (1.07–2.85) Rice and pasta: Moderate: 1.73 (1.12–2.68) High: 0.94 (0.55–1.61) Juices: Moderate: 1.34 (0.81–2.20) High: 1.75 (1.11–2.77) | Turn around / evening 1530 ± 629 54.2 ± 17.8 37.2 ± 52.3 29.2% 262.3% 494.3% |
| Sudo N et al, 2001 (39) | DR-4 days | Nutrient adequate rate (NAR) for calories, macronutrients (g) Calcium (mg) and iron (mg). NAR energy: NAR for calories consumed from snacks, breakfast, lunch and dinner NAR = amount consumed / RDA 100 | Day shift Worked days Calories: 1954.9 ± 392 kcal Protein: 71.2 ± 17.9 g/day LIP: 58.0 (42.6 67.6 %) CHO: 277.5 (241.0% 309.8%) Calcium: 499.8 (372.3% 652.8%) Iron: 9.2 (7.5% 11.9%) | Shift: Morning: 1700.9 ± 426.2 LIP: 60.7 ± 60.0g CHO: 277.5 (241.0% 309.8%) Calcium: 499.8 (372.3% 652.8%) Iron: 9.2 (7.5% 11.9%) Days off: CHO: 243.5 (190.9% 292.5%) NAR (%): 99.5 ± 27.0 Alcohol: 81±9.0 kcal | Turn around / evening 1530 ± 629 54.2 ± 17.8 37.2 ± 52.3 29.2% 262.3% 494.3% |

Table 6. Summary of the main results of studies that evaluated calorie intake, nutrients, food groups and eating patterns (N=15). [FFQ=Food Frequency Questionnaire; DR=dietary record; 24HR=24-hour dietary recall; NS=not significant; NSP=not specified; OR=odds ratio; CI=confidence interval; HDI score=Healthy Diet Indicator Score; SFA=saturated fatty acid; PUFA=polyunsaturated fatty acid; PTN=protein.]
### Table 6. Continued

| Study | Work shift | Dietary survey used | Information assessed eating habits | Significant results |
|-------|------------|---------------------|------------------------------------|---------------------|
| Vimalananda, et al, 2015 (22) | Day shift | FFQ | Average energy intake (kcal), Frequency of regular food consumption: Coffee= 1 cup / day, Decaffeinated coffee= 1 cup / day, Soft drinks= 1 cup / day, Diet soft drinks= 1 cup / day, Dietary pattern: 5th quintile of food groups intake: “Fruits and vegetables” (FV): More healthy; “meat/ fried foods” (FF): Less healthy | Day shift: Calories: 1434 kcal, Alcohol: 26%, Coffee: 8%, Decaffeinated coffee: 2%, Soft drinks: 5%, Fast food: 2%, Diet soft drinks: 2%, 5th quintile consumption: FV: 20%, FF: 19% |
| Han et al, 2016 (33) | Fixed day or later rotating = with night shifts / no night shifts | Food habits questionnaire | Irregular meals consumed/day (yes or no); Frequency of meals/day; Hours of full meals and snacks; Consumption of food according to Korean recommendation: Dairy; proteins; vegetables; fruits; fried food; fatty foods and carbohydrates snacks | Fixed shift: With night No night: Calories: 86.9 65.7 |
| Cody et al, 2014 (36) | Fixed / day = morning (04:00–09:00), day (07:00–15:00) or afternoon (15:00–23:00) Night / rotating = Only night or rotating shift including night shifts (23:00-07:00) | FFQ | Alcohol intake (g/day), caffeine (mg/day) and calories (kcal/day); Healthy diet score (AHEI) ranging from 0 (no adhesion) to 110 (perfect adhesion) | Fixed shift/day Caffeine intake (mg/day): 167 ± 136 Total energy (kcal / day): 1772 ± 547 AHEI score: NS |
| Hulsegge et al, 2016 (19) | Fixed: Any shift not considered rotational Rotation = late (up to 00h); night (after 00h); “Sleep” (sleep at work) Number of working nights (00:00–05:00) = no; 1–4 or > 5 | FFQ | Energy intake (kcal/day) and percentage of macronutrient contribution (% EI) Average intake (g/day) and percentage contribution of calories from food groups (% EI) Mediterranean dietary pattern score (MDG) and WHO recommendations (HDI). Highest score = healthier eating pattern | Fixed shift Kcal/day: 1990 (IQR 1670-2391) PTN: 15.9 (IQR 14.5 - 17.5) Cholesterol (mg): 211 (IQR 167-261) Cereals (g/day) 49 (26-77) Fish (g/day): 8.0 (IQR 3.3 - 14.9) Meat (g/day): 102 (IQR 62-136) Milk (g/day): 346 (IQR 197-541) Cakes/cookies (g/day) 25 (IQR 13-41) HDI SCORE: NS |
| | | | Rotating shift | 2222 (IQR 1826-2700) β: 56kcal/day (95% CI 10-101) 15.8 (IQR 14.4-17.3) β: 0.29 (95% CI 0.1-0.46) | 232 (IQR 184-287) β: 0.10 (95% CI 0.03-0.17) 58 (IQR 34-96) β: 0.89 (95% CI 0.3-1.6) 82 (IQR 57-148) β: 0.9 (95% CI 0.1 - 1.8) 118 (IQR 78-159) β: 0.31 (95% CI 0.46-0.46) 358 (IQR 181-580) β: 0.56 (95% CI 0.4-1.01) 23 (IQR 11-40) β: 0.3 (95% CI 0.6-0.1) 23 (IQR 11-40) β: 0.3 (95% CI 0.6-0.1) 23 (IQR 11-40) Number of nights worked/month > 5 nights / month: Energy intake: β: 1.03 (95% CI 0.29-1.76) Meat (g/day): β: 12 (4-19) Cholesterol: β: 15 (5-26) |
| Study                  | Work shift | Dietary survey used | Information assessed eating habits                                                                 | Significant results |
|-----------------------|------------|---------------------|------------------------------------------------------------------------------------------------------|---------------------|
| Morikawa et al, 2008 (43) | Fixed = non-rotating; Rotating = shifts alternating every 5 days, Beginning 08:00, 16:30 and 00:15h + rest of the weekend; or alternated every 3 to 4 days, starting 06:30, 21:30 + 3h or resting one day every shift change | FFQ | Energy intake (kcal/day), percentage of calories macro and micronutrients (% EI), consumption of nutrients (mg/1000kcal) of calcium, iron, sodium, potassium, Vitamins: A, B1 and C; alcohol fibers. Stratification by age Consumption of food groups (g/1000kcal): vegetables, meats and dairy products | Fixed shift 20–29 years: SFA: 5.9 ± 1.7% EI; Calcium: 180.8 ± 95.7 mg/1000kcal; Potassium: 895 ± 254 mg/1000kcal. VitA: 314 ± 166 mg/1000kcal; VitB1: 0.345 ± 0.108 mg/1000kcal; Milk: 27.2 ± 3.2 g/1000kcal. FFQ Energy intake (kcal/day), percentage of calories macro and micronutrients (% EI), consumption of nutrients (mg/1000kcal) of calcium, iron, sodium, potassium, Vitamins: A, B1 and C; alcohol fibers. Stratification by age Consumption of food groups (g/1000kcal): vegetables, meats and dairy products |
| Pan et al, 2011 (32)  | Rotating (RT): day shift + 3 nights/month Time in work shift: Never, 1 or 2; 3 to 9; 10 to 19; >20 years | FFQ | Energy and macronutrients intake Diabetes Score: low-risk diet, "poor" in trans fat and glycemic index, high in fiber and higher ratio of polyunsaturated fatty acids | NS |
| Waterhouse et al, 2003 (49) | Day shift: 09:00–18:00 Night: 20:00–6:00 | Food habit questionnaire | Meal Frequency (cold, hot meals small, large hot meals, and snacks during the working days) | Day shift Snacks: 0.21 Hot meals: 0.10 Cold foods: 0.05 Hot foods: 0.23 Night shift Snacks: 0.04 Hot meals: 0.36 |
| Bonell et al, 2017 (48) | Same subject working in different shifts = 2 working days (10h), followed by 2 days of working nights (14h) +4 days off | 4 24HR (2 each working schedule) | Energy intake (kcal/day), percentage (% EI) macronutrients, number of meals consumed, energy density (ED- kcal/g/day) | Day shift % (EI) Sugars: 15.5% (11.3–19.7) Food consumed: 27.5 (21.5–30) ED: 5.52kcal/g/day (4.72–5.83) Night shift 16.8% (14.2–19.6) Food consumed: 25 (20–30) ED: 5.73kcal/g/day (5.08–6.88) |
| Lasfargues et al, 1996 (52) | Day shift = NS Night shift = NS | FFQ and food habits questionnaire | Frequency of meals and consumption of food groups. Fat intake frequency: >130g / (men); >95 (women) and cholesterol: >550mg (men); >450mg (women). | Day shift Not eat breakfast every day: Men: 25.1% Not eat lunch >1 time/week: Men: 3.2%; Women: 6.7% Water consumption <1 liter/day Men: 68.9%; Women: 72.5% Sweet drinks> 0.5 liters/day: Men: 7.6%; Women: 2.6% Dairy products (<3 times per week) Men: 35.4%; Women: 78.1% Bread (>200 g/day) Men: 21% Calcium (mg/day) Women: 1020 ± 170 | Night shift 32.8 Not eat lunch >1 time/week: Men: 3.2%; Women: 6.7% Water consumption <1 liter/day Men: 68.9%; Women: 72.5% Sweet drinks> 0.5 liters/day: Men: 7.6%; Women: 2.6% Dairy products (<3 times per week) Men: 35.4%; Women: 78.1% Bread (>200 g/day) Men: 21% Calcium (mg/day) Women: 1020 ± 170 | Night shift 32.8 Not eat lunch >1 time/week: Men: 3.2%; Women: 6.7% Water consumption <1 liter/day Men: 68.9%; Women: 72.5% Sweet drinks> 0.5 liters/day: Men: 7.6%; Women: 2.6% Dairy products (<3 times per week) Men: 35.4%; Women: 78.1% Bread (>200 g/day) Men: 21% Calcium (mg/day) Women: 1020 ± 170 |

* Night shift differs from both groups.
* Night shift differs from the morning shift.
* Afternoon/evening shift differs from daytime workers.
* Afternoon/evening shifts differs from both groups.
### Table 7. Summary of associations between eating habits and shift work (N=33).

| Quantitative analysis                     | Higher in shift workers | Higher in day/fixed workers | No significant association |
|-------------------------------------------|-------------------------|-----------------------------|---------------------------|
| Energy intake (N=16)                      | 5 (11, 19, 22, 36,38)   | 2 (39,42)                   | 9 (32, 43-48, 52,53)      |
| Protein (N=12)                            | 1 (11)                  | 3 (39, 19, 42)              | 6 (32, 38, 43, 46, 47,48) |
| Carbohydrates (N=11)                      | 2 (38, 45)              | 4 (11,39,42)                | 6 (19, 32, 43, 46, 47,48) |
| Fats (N=12)                               | 2 (11, 38)              | 2 (39,42)                   | 6 (19, 32, 43, 46, 47,48) |
| Saturated fat (N=5)                       | 3 (43, 46, 52)          | 1 (42)                      | 1 (19)                    |
| Fiber (N=3)                               | 2 (42,43)               | -                           | 1 (19)                    |

#### Qualitative analysis

**Food groups**

| Starchy foods (N=9)                   | 3 (19, 28, 52)         | 3 (21, 45, 50)              | 3 (6, 28, 32)             |
| Fruit and vegetables (N=10)           | 3 (7, 50, 53)          | 4 (7, 21, 33, 45)           | 3 (28, 32, 40)            |
| Meat and animal protein (N=8)         | 3 (6, 19, 28)          | 2 (21, 45)                  | 3 (32, 33, 43)            |
| Sweets (N=5)                          | 2 (45, 48)             | 2 (19, 42)                  | 1 (6)                     |
| Soft drinks (N=8)                     | 5 (21, 22, 28, 45, 52) | -                           | 2 (19, 32, 50)            |
| Oils and fats (N=6)                   | 2 (6,21)               | (1) 43                      | 3 (6, 40, 52)             |
| Alcoholic beverages (N=9)             | 2 (45, 53)             | 2 (22, 44)                  | 5 (32, 36, 40, 43, 50)    |

**Quality scores or dietary pattern**

| Risk score/unhealthy pattern (N=9)     | 2 (54, 22)             | (6)                         | 6 (17, 19, 32, 36, 37 55) |

**Meal Pattern**

| Number of meals (N=6)                  | 2 (17, 21)             | 2 (33, 34)                  | 2 (45, 49)                |
| Skip meals (N=4)                       | 4 (17, 33, 35, 52)     | -                           | 1 (31)                    |
| Eating at night (N=6)                  | 5 (17, 21, 33, 41, 46) | -                           |                           |

intake is susceptible to memory and information bias, particularly underreporting (75); additionally, there was no information about the validity of the meal pattern questionnaires and the simple questions used in several studies. Although there are limitations, food questionnaires (food recalls, food records and FFQ) are the most widely used methods for assessing food consumption in observational studies due their simplicity and low cost (75). In the quality assessment of the studies, the outcome measurements were classified as having a low risk of bias due to the characteristics of the quality checklist adopted. (30)

Differences in exposure ratings should be considered. The routine of workers subjected to fixed night or day work may differ from that of workers who perform their activities on a rotating shift scale, implying different feeding, sleep and leisure times between groups and limiting comparability between them. In addition, some studies were not clear in the shift system rating (35, 40, 50, 53, 54), and none of the studies presented an instrument for the classification of shifts, for example, payroll, registration forms or access to information recorded at the workplace. It is known that the self-report of the working shift system has low sensitivity and moderate specificity, compared with objective data (76).

The investigation of eating habits by the studies included in this review was conducted under different contexts, such as food availability at the work place, place and time for worker meals, type of company and work (traveling/driving workers, blue or white collar workers, hospital or industrial workers), and cultural habits (food differences in Eastern and Western countries). These differences can explain the heterogeneity in the methods and results of the studies.

Despite the division of outcomes into nutritional composition or food and food groups in most articles, the results summary and evaluation allow a broad understanding of dietary habits. Likewise, the collection of information that characterizes an eating pattern (both the quantity and quality of food and the temporal distribution of eating across the 24 hours in a day) allows the adequate identification of risk behaviors and interventions that may modify them.

**Concluding remarks**

This was the first systematic review of literature to investigate the association between shift work and eating habits. Although quantitative differences in calorie intake are not influenced by work shift, the timing of meals consumed and the pattern of eating seem to be different in shift workers. Shift workers also have a higher consumption of foods rich in saturated fats and sugar. The alterations in sleep-wake cycles in addition to unhealthy food habits have a possible mediating role in the relation between shift work and chronic diseases.

The results of this review highlight the need for attention to the quality of food these workers eat and the need for future specific studies regarding the association between shift work and eating habits. The methodology of these studies should consider the use of longitudinal designs, the statistical power and representativeness of the sample, objective methods for work shift measurement, the assessment of food habits based on different
indicators (calories, nutrients, food and meal patterns) and the control of possible confounding factors, such as sleep characteristics, time of exposure to shift work and duration of the work shift. These studies are fundamental in proposing nutritional guidelines specific to the population of shift workers.

Ethics

The authors declare no conflicts of interest.

References

1. Canuto R, Teresa Anselmo Olinto M, Pascoal Pattussi M, Liane Henn R, Block Macagnan J. Associated factors with metabolic syndrome in shift workers. Sleep Med. 2013;14:e89. https://doi.org/10.1016/j.sleep.2013.11.185

2. Morshead DM. Stress and shiftwork. Occup Health Saf. 2002;71(4):36-38.

3. Moreno, CRC, Fischer, FM, Rotenberg, L. A saúde dos trabalhadores na sociedade 24 horas. [Workers’ health in society 24 hours]. São Paulo em Perspect. v. 17, n. 1, p. 34-46, 2003. https://doi.org/10.1590/S0102-883920003000100005

4. Waterhouse JM, Folkard S, Minors DS. Shiftwork, health and safety. An overview of the scientific literature- 1978-1990. HSE. 1992;31.

5. Amani R, Gill T. Shift working, nutrition and obesity: Implications for workforce health - A systematic review. Asia Pac J Clin Nutr. 2013;22(4):505-15. https://doi.org/10.6133/apjcn.2013.22.4.11.

6. Barbadoro P, Santarelli L, Croce N, et al. Rotating shift-work as an independent risk factor for overweight Italian workers: a cross-sectional study. PLOS One. 2013;8(5):e63289. https://doi.org/10.1371/journal.pone.0063289

7. Balieiro LC, Rossato LT, Waterhouse J, Paim SL, Mota MC, Crispim CA. Nutritional status and eating habits of bus drivers during the day and night. Chronobiol Int. 2014;31(10):1123-1129. https://doi.org/10.3109/07420528.2014.957299

8. Chen CC, Shiu LJ, Li YL, Tung KY, Chan KY, Yeh CJ et al. Shift Work and Arteriosclerosis Risk in Professional Bus Drivers. Ann Epidemiol. 2010;20(1):60-66. doi.org/10.1016/j.annepidem.2009.07.093

9. Fischer FM, Moreno CRdC, Fernandez Rde L, Berwerth A, dos Santos AM, Bruni Ade C. Day- and shiftworkers’ leisure time. Ergonomics. 1993;36(1-3):43-49. https://doi.org/10.1080/00140139308967853

10. Buss J. Associations between obesity and stress and shift work among nurses. Workplace Health Saf. 2012;60(10):453-458. https://doi.org/10.1177/216507991206001007

11. Crispim CA, Waterhouse J, Damaso AR, Zimberg IZ, Padilha HG, Oyama LM et al. Hormonal appetite control is altered by shift work: a preliminary study. Metabolism. 2011;60(12):1726-1735. https://doi.org/10.1016/j.metabol.2011.04.014

12. Mota MC, De-Souza DA, Rossato LT, Silva CM, Araújo MB, Tufik S et al. Dietary patterns, metabolic markers and subjective sleep measures in resident physicians. Chronobiol Int. 2013;30(8):1032-1041. https://doi.org/10.3109/07420528.2013.796966

13. Bonham MP, Bonnell EK, Huggins CE. Energy intake of shift workers compared to fixed day workers: A systematic review and meta-analysis. Chronobiol Int. 2016;33(8):1086-1090. https://doi.org/10.1080/07420528.2016.1192188

14. Crispim CA, Tufik S, Padilha H, Dattilo M, Zimberg IZ, Mello MT. Shift work and nutritional aspects: a review. Nutrire: rev. Soc. Bras. Alim. Nutr. 2009;34(2):213-227.

15. Crispim CA, Zimberg IZ, Padilha HG, Tufik S, de Mello MT. 003 Circadian Concentrations of Leptin and Non-acylated and Acylated Ghrelin in Fixed-shift Workers. Sleep Med. 2009;10, Supplement 2:S1-S2. https://doi.org/10.1016/S1389-9457(09)70005-X

16. Padilha HG, Crispim CA, Zimberg IZ, Folkard S, Tufik S, de Mello MT. Metabolic responses on the early shift. Chronobiol Int. 2010;27(5):1080-1092. https://doi.org/10.3109/07420528.2010.489883

17. de Freitas ES, Canuto R, Henn RL, Olinto BA, Macagnan JB, Pattusi MP et al. Alteration in eating habits among shift workers of a poultry processing plant in southern Brazil. Cien Saude Colet. 2015;20(8):2401-2410.

18. 11th International Conference on the physiology of food and fluid intake: University of Oxford, U.K., 28–30 July 1993. Appet. 1993;21(2):161-219.

19. Hulsegge G, Boer JM, van der Beeck AJ, Verschuren WM, Sluijs I, Vermeulen R et al. Shift workers have a similar diet quality but higher energy intake than day workers. Scand J Work Environ Health. 2016;42(6):459-468. https://doi.org/10.5271/sjweh.3593

20. Bertéus Forslund H, Lindroos AK, Sjöström L, Lissner L. Meal patterns and obesity in Swedish women—a simple instrument describing usual meal types, frequency and temporal distribution. Eur J Clin Nutr. 2002 Aug;56 (8):740-7. https://doi.org/10.1038/sj.ejcn.1601387

21. de Assis MA, Nahas MV, Bellisle F, Kupek E. Meals, snacks and food choices in Brazilian shift workers with high energy expenditure. J Hum Nutr Diet. 2003; 16(4):283-289. https://doi.org/10.1046/j.1365-277X.2003.00448.x

22. Vimalananda VG, Palmer JR, Gerlovin H, Wise La, Drivers. Ann Epidemiol. 2010;20(1):60-66. https://doi.org/10.1016/j.annepidem.2009.07.093

23. Souza et al 2013. https://doi.org/10.1016/j.apjcn.2013.22.4.11.

24. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151(4):264-269, W264.
Shift work and eating habits

25. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA. 2000;283(15):2008-2012. https://doi.org/10.1001/jama.283.15.2008

26. Bilski B. Influence of shift work on the diet and gastrointestinal complains among nurses. A pilot study. Med Pr. 2006;57(1):15-19.

27. Morris CJ, Yang J, Garcia JI. Simulated night work acutely impairs glucose tolerance. Sleep. 2013;36:A182.

28. Fernández Rodríguez Ma J, Sánchez-Villegas A, Bello Luján L, Serra Majem L. Food habits and life styles of shift workers in the Las Palmas de Gran Canaria town council. Rev. esp. nutr. comunitaria. 2009;15(3):157-162.

29. Bae JM. A suggestion for quality assessment in systematic reviews of observational studies in nutritional epidemiology. Epidemiol Health. 2016;38:e2016014. https://doi.org/10.4178/eph.2016014

30. Herzog R, Álvarez-Pasquin MJ, Díaz C, Del Barrio JL, Estrada JM, Gil A. Are healthcare workers’ intentions to vaccinate related to their knowledge, beliefs and attitudes? A systematic review. BMC Public Health. 2013;13:154. https://doi.org/10.1186/1471-2458-13-154

31. Lin YC, Hsiao TJ, Chen PC. Persistent rotating shift-work exposure accelerates development of metabolic syndrome among middle-aged female employees: A five-Year follow-Up. Chronobiol Int. 2009;26(4):740-755. https://doi.org/10.1080/074205209029029029

32. Pan A, Schernhammer ES, Sun Q, Hu FB. Rotating night shift work and risk of type 2 diabetes: Two prospective cohort studies in women. PLOS Med. 2011;8(12).https://doi.org/10.1371/journal.pmed.1001141

33. Han K, Choi-Kwon S, Kim KS. Poor dietary behaviors of and some reasons for, differences in eating habits between day and night workers. Chronobiol Int. 2003;20(6):1075-1092. https://doi.org/10.1080/07420528.2013.872120

34. Herzig R, Thompson PM, Wittert G, Vetter L, Fiedorowicz JG, Alpert JS et al. Increased triglyceride levels in shift workers. Am J Epidemiol. 2008;168(2):235-243. https://doi.org/10.1093/aje/kwn361

35. Lin YC, Hsiao IC, Chen PC. Long-term day-and-night rotating shift work poses a barrier to the normalization of alanine transaminase. Chronobiol Int. 2014;31(4):487-495. https://doi.org/10.1080/07420528.2013.872120

36. Hemio K, Puttonen S, Viitasalo K, Harma M, Peltonen M, Aittomäki K. Risk factors for metabolic syndrome among middle-aged women. Scand J Public Health. 2006;34(2):140-149. https://doi.org/10.1177/140349480603400207

37. Zhao I, Bogossian F, Song S, Turner C. The association between shift work and unhealthy weight: A cross-sectional analysis from the nurses and midwives’ e-cohort study. J Occup Environ Med. 2011;53(2):153-158. https://doi.org/10.1097/JOM.0b013e318205e1e8

38. Schiavo-Cardozo D, Lima MMO, Pareja JC, Geloneze B. Appetite-regulating hormones from the upper gut: Disrupted control of xenin and ghrelin in night workers. Clin Endocrinol. 2013;79(6):807-811. https://doi.org/10.1111/cen.12114

39. Sudo N, Ohtsuka R. Nutrient intake among female shift workers in a computer factory in Japan. Int J Food Sci Nutr. 2001;52(4):367-378. https://doi.org/10.1080/09637480120057530

40. Chen C-C, Shiu L-J, Li Y-L, Tung KY, Chan KY, Yeh CJ et al. Shift Work and Arteriosclerosis Risk in Professional Bus Drivers. Ann Epidemiol. 2010;20(1):60-66. https://doi.org/10.1016/j.annepidem.2009.07.093

41. Lin YC, Hsieh IC, Chen PC. Long-term day-and-night rotating shift work poses a barrier to the normalization of alanine transaminase. Chronobiol Int. 2014;31(4):487-495. https://doi.org/10.1080/07420528.2013.872120

42. Lennermäki S, Akerstedt T, Hambraeus L. Nocturnal eating and serum cholesterol of three-shift workers. Scand J Work Environ Health. 1994;20(6):401-406. https://doi.org/10.1080/07420528.2013.872120

43. Morikawa Y, Miura K, Sasaki S, Yoshita K, Yoneyama, Sakurai M et al. Evaluation of the effects of shift work on nutrient intake: a cross-sectional study. J Occup Health. 2008;50(3):270-278. https://doi.org/10.1539/joh.L7116

44. Romon M, Nuttens MC, Fivet C, Pot P, Bard JM, Furon D et al. Increased triglyceride levels in shift workers. Am J Med. 1992;93(3):259-262. https://doi.org/10.1016/0002-9343(92)90230-9

45. De Assis MAA, Kupek E, Nahas MV, Bellisle F. Food intake and circadian rhythms in shift workers with a high workload. Appetite. 2003;40(2):175-183. https://doi.org/10.1016/S0195-6663(02)00133-2

46. Esquirol Y, Bongard V, Mabile L, Jonnier B, Soulat JM, Perret B. Shift work and metabolic syndrome: respective impacts of job strain, physical activity, and dietary rhythms. Chronobiol Int. 2009;26(3):544-559. https://doi.org/10.1080/07420520902821176

47. Pasqua IC, Moreno CR. The nutritional status and eating habits of shift workers: a chronobiological approach. Chronobiol Int. 2004;21(6):949-960. https://doi.org/10.1080/07420520410001332

48. Bonnell EK, McCaffrey TA, Palermo C, Bonham MP. Influences on Dietary Choices during Day versus Night Shift in Shift Workers: A Mixed Methods Study. Nutrients. 2017;9(3).https://doi.org/10.3390/nu9030193

49. Waterhouse J, Buckley P, Edwards B, Reilly T. Measurement of, and some reasons for, differences in eating habits between night and day workers. Chronobiol Int. 2003;20(6):1075-1092. https://doi.org/10.1081/CBI-120025536

50. Henningson S, Olsson G, Lindblom J, Lindstrom J. Food and nutrient intake among workers with different shift systems. Occup Environ Med. 2015;72(7):513-520. https://doi.org/10.1136/oemed-2014-102624

51. Diaz-Sampedro E, López-Maza R, González-Puente M. Eating habits and physical activity in hospital shift workers.
Brown AW, Bohan Brown MM, Allison DB. Belief beyond the evidence: using the proposed effect of breakfast on obesity to eat? The influence of circadian rhythms on metabolic health: are animal studies providing the evidence? Nutr Res Rev. 2016;29(2):180-193. https://doi.org/10.1017/S095442411600010X

Kuehn BM. Resetting the Circadian Clock Might Boost Metabolic Health. JAMA. 2017. https://doi.org/10.1001/jama.2017.0653

Arble DM, Ramsey KM, Bass J, Turek FW. Circadian disruption and metabolic disease: Findings from animal models. Best Pract Res Clin Endocrinol Metab. 2010;24(5):785-800. https://doi.org/10.1016/j.beem.2010.08.003

Hatori M, Vollmers C, Zarrinpar A, DiTacchio L, Bushong EA, Gill S et al. Time-restricted feeding without reducing caloric intake prevents metabolic diseases in mice fed a high-fat diet. Cell Metab. 2012;15(6):848-860. https://doi.org/10.1016/j.cmet.2012.04.019

Aljuaraiban GS, Chan Q, Oude Griep LM, Brown IJ, Daviglus ML, Stamler J et al. The Impact of Eating Frequency and Time of Intake on Nutrient Quality and Body Mass Index: The INTERMAP Study, a Population-Based Study. J Acad Nutr Diet. 2015;115(4):528-536.e521. https://doi.org/10.1016/j.jand.2014.11.017

Scheer FAJL, Hilton MF, Manzoros CS, Shea SA. Adverse metabolic and cardiovascular consequences of circadian misalignment. Proc Natl Acad Sci. 2009;106(11):4453-4458. https://doi.org/10.1073/pnas.0808180106

Cipolla-Neto J, Amaral FG, Afecte SC, Tan DX, Reiter RJ. Melatonin, energy metabolism, and obesity: a review. J Pineal Res. 2014;56(4):371-381. https://doi.org/10.1111/jpi.12137

Richelsen, B. Sugar-sweetened beverages and cardio-metabolic disease risks. Curr Opin Clin Nutr Metab Care. 2013; 16(4): 478484. https://doi.org/10.1097/MCO.0b013e328361c53e

Vyas MV, Garg AX, Iansavichus AV, Costella J, Donner A, Laugsand LE, et al. Shift work and vascular events: systematic review and meta-analysis. BMJ. 2012;345:e4800 https://doi.org/10.1136/bmj.e4800

Korsiak J, Trammer J, Day A, Aronson KJ. Sleep duration as a mediator between an alternating day and night shift work schedule and metabolic syndrome among female hospital employees. Occup Environ Med. 2018 Feb;75(2):132-138. https://doi.org/10.1136/oemed-2017-104371

Willet W. Nutritional Epidemiology. Oxford: Oxford University Press1998. https://doi.org/10.1093/acprof:o so/9780195122978.001.0001

Härmä M, Koskinen A, Ropponen A, Puttonen S, Karhula K, Vahtera J et al. Validity of self-reported exposure to shift work. Occup Environ Med. 2017;74(3):228-230. https://doi.org/10.1136/oemed-2016-103902

Received for publication: 23 January 2018