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The effect of shift work on eating habits: a systematic review

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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

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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.

Table 1. The PICO strategy

Criteria	Definition
Population	Health adult workers
Intervention/exposure	Shift work: night work or rotating shift work
Comparison	Day work, regular work
Outcomes	Eating habits: consumption of calories, nutrients, food groups or meal patterns

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 evalua-

Table 2. Search strategy for PubMed/Medline.

Exposure:	"Shift systems" OR "shift system" OR "Shift work" OR "Shift-work" OR "Night shift work" OR "Night shift-work" OR "Night-work" OR "Night worker" OR "Night workers" OR "shift workers" OR "shift worker" OR "Sleep disorder" OR "Sleep disorders" OR "Circadian Rhythm" OR "Circadian Rhythms" OR "rotating shift work" OR "rotating shift-work"
Outcome:	"Meal frequency" OR "meal frequencies" OR "meals" OR "meal time" OR "mealtime" OR "mealtimes" OR "meal times" OR "eating frequency" OR "eating frequencies" OR "eating episodes" OR "meal pattern "OR" meal patterns "OR" eating pattern "OR" eating patterns "OR" behaviors eating "OR" eating behavior "OR" dietary pattern "OR" dietary patterns "OR" dietary habits "OR" diet habit "OR" diet habits "OR" food intake "OR" foods intake "OR" nutrient intake "OR" nutrient intake "OR" caloric intake "OR" caloric intake "
Limit	"Humans"

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 107 615 (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, 38, 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) [a]					Score [b]
				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)	1988–2008 (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
Cross-sectional									
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	7856	-	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	2510	-	61.5 [c] 62.3 [d]	10.1 [c] 9.3 [d]			77.8
Hemiõ K et al, 2015 (50)	2006–2009	Men and women – aviation company in Finland	1478		NR				77.8
Wirth M et al, 2014 (54)	2005–2010	American Men and women – population-based	7643	20–80	-	-			77.8
Cody A et al 2015 (36)	1989–2009	American women – nurses	54 724	25–42	-	-			77.7
Kin M et al, 2013 (35)	2011	Korean women, nurses	9989	-	33.2	-			66.7
Li Y et al, 2011 (53)	1987–1990	Japanese men and women – population-based	6712	20–59					66.7
Barbadoro P et al, 2013 (6)	2008	Italian men – steel workers	339	-	42.1 [c] 48.6 [d]	12.2 [c] 8.3 [d]			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)	2002–2007	Chinese men – electronics factory	1196	-	32.5	6.0			66.7
Zhao I et al 2011 (37)	2006–2008	Women, Australian, New Zealand and British, nurses	2494	-	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	2400	30–29	-	-			66.7
Balieiro LC et al, 2014 (7)	April–Dec / 2012	Brazilian men, bus drivers	150	-	46.7 [c] 44 [e]	9.9 [c] 8.5 [e]			55.6
Rodriguez M et al, 2009 (28)	2000-2001	Spanish men and women, hospital workers	417	24–65	-	-			55.6
Morikawa Y et al, 2008 (43)	2003	Japanese men- metal company	2254	20–59	-	-			55.6
Monique R et al, 1992 (44)	1988–1989	French men – plant operators	63	-	32.4 [c] 31.9 [d]	-			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)	NR	Women Brazilian hospital cleaning-service	24		20–40	-			44.4
Crispim CA et al, 2011 (11)	NR	Brazilian men, steel workers	22	-	26.7 [c] 31.8 [f] 30.1 [e]	2 [c] 1.5 [f] 1.4 [e]			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				28 [c] 26 [f] 25 [g]	25–31 [c] 24–29 [f] 20–28 [g]	33.3
Waterhouse J et al, 2003 (49)	NR	British men and women – nurses	93				25 [c] 26 [h] 43 [i]	22–27 [c] 24–29 [h] 40–46 [i]	33.3
Bonell EK et al, 2017 (48)	NR	Australian men – firefighters	41				36	30–52	33.3

[a] Age (years) expressed in mean ± standard deviation, age (up minimum) or median (interquartile range).
[b] Assigned from the quality analysis (%).
[c] Day shift; [d] Shift work; [e] Night shift; [f] Morning shift; [g] Afternoon shift; [h] Night shift I; [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 starchy 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 starchy 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 ± 366,63kcal PTN = 20.2 ± 1.1% CHO= 45.3 ± 1.6% LIP = 34.4 ± 1.9%	Day 3549 ± 365 kcal 16.2 ± 0.6% 59,6,3 ± 1.4% 24.2 ± 1.3%	Night 3461 ± 114 kcal [a] 23.1 ± 0.5% 48.7 ± 1.6% [b] 28.2 ± 1.7% [b]
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 + 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 ± 4.69 Saturated fatty acids (g / day): 32.3 ± 0.96 BK: 13.85 ± 0.83% EI L: 41.18 ± 0.76% EI S2: 2.32 ± 0.34% EI S3: 0.38 ± 0.1% EI	Rotating shift 5.19 ± 0.08 35.78 ± 0.99 9.95% ± 0.70 38.3% ± 0.76 3.48% ± 0.42 3.84% ± 0.44	
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 9.3 (0.53–57)	
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: 50.39 ± 12.47	Night shift 315.88 ± 2043 281.26 ± 65.37 65.76 ± 23.38)	
Lennernas M et al, 1994 (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 51 ± 16 48 ± 18 53 ± 16 59 ± 24 52 ± 21 48 ± 18 47 ± 19	Night 35 ± 10 35 ± 10 35 ± 11 35 ± 18 34 ± 16 35 ± 13 37 ± 13

[a] Statistical significant difference between night and morning workers.
[b] Statistical significant difference between night and day workers.

with unhealthy eating patterns (22) and inflammatory potential (54), characterized by the consumption 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 Rotating = Start rotating at different times on different days or weeks Rotating working time: > 10 years; <10 years	FFQ	Food groups: alcohol, coffee, fruits and vegetables	NS			
Barbadoro et al, 2013 (6)	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 Plate 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 (35)	Regular = NSP Shifts NSP = Working time in shifts: 1st tertile: 0.08–3 years 2d tertile 2: 3.08– 6.75 years 3rd tertile: 6.83–38 years	Meal pattern questionnaire	Meal consumption = breakfast, lunch and dinner	Regular: skip breakfast: 29.2%; skip lunch: 0.5%; skip dinner: 0.8%	Shift work: 43.1%; 2.5%; 1.1%	Tertile – shifts: skip breakfast: 1st: 43.2%; 2nd: 47.1%; 3rd: 38.4% skip lunch: 1st: 2.9%; 2nd: 2.0%; 3rd: 1.1% skip dinner: 1st: 1.2%; 2nd: 1.3%; 3rd: 0.8%	
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%	Shift work: 59.42%; 40.58% OR = 0.60 (95% 0,39–0.82) 60.22%; 39.78% OR = 1.45 (95% 1,02– 2.06) 56.9% ; 43.1% OR= 1.28 (95% 1,03–1.50) 25.38%; 13.8%; 3.93%		
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 Regular intake of alcohol = ≥1 time / week, for a year	Day shift: Snacks before bed: 35.5% Regular consumption of alcohol: 7.2%	Rotating shift: 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 (079–094)	Afternoon / evening: 0.96 (0.80–1.13)	Rotating: 1.07 (0.92–1, 22) [a]	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 late afternoon and evening	Dietary quality questionnaire: Australian Recommended Food Score (ARFS)	Food score of 74 points Higher scores = better diet quality	NS			

Continued

Table 5. Continued

Study	Work shift	Dietary survey used	Information assessed - eating habits	Significant results		
Zverev 2005 (34)	Day shift = fixed shift without night work Rotating = 5 working days from 07:00–17:00; 3 nights from 17:00–07:00 and 5 days off	Meal pattern questionnaire	Number of meals (main and snacks) on working days and rest	Day shift: work days meals: 2.26 ± 0.59		Rotating shift: Day: 2.06 ± 0.68; Night = 1.12 ± 0.50; Day off = 2.44 ± 0.81
Hemiõ 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 [c] ≥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 (serving/week)	**Day shift :** **Vegetables [b]: 63%;** **Fruits [b]: 44%;** **HFM: 1.3;** **Breads [b]: 3.2%;** **Oils for breads: 75% and 67%;** **Cheese [c]: 2.7%**	Irregular: 49%; 38%; 1.2; 3.4%; 70% and 65%; 3.2%	**In flight:** **64%;** **52%;** **1.5 [b];** **2.6%;** **57% and 54%;** **6.9%** **Others = NS**
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 Score food risk. Risk consumption ≥3rd tertile.	**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%; 50.6%; 89.1%; 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.

ing that there are no differences in the energy intake of rotating/night shift workers when compared to daytime workers. Moreover, only three studies evaluated the micronutrient intake of workers, demonstrating the need for more studies with this approach.

The results of this review should be interpreted in the light of the methodological characteristics of the included studies. One limitation of the cross-sectional study design is that the exposure and outcome are simultaneously assessed. In this sense, it is not possible to affirm if workers adopted these eating habits after or before beginning to work in the current shift pattern.

The articles were found to show low methodological quality, mainly in relation to controlling for confounding factors. In most studies, the association between eating habits and shift work was not the main objective, so the analyses did not consider possible confounding factors. Sleep pattern, for example, is an important mediating factor of circadian and metabolic disorders (1, 5, 65, 74). Thus, studies evaluating the relation between working shifts and eating habits should consider the aspects related to quality and duration of sleep. Another criterion evaluated with a high risk of bias was the selection of workers. Samples for convenience, without 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

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.]

Study	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 (45)	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	Afternoon	Night
				CHO (g): 407.6±13.4	459.9 ± 21.1	503.4 ± 27.5 [a]
				FV: 110 ± 10.5kcal	151 ± 12.3	272 ± 16.5
				Starches: 1234 ± 35.1 kcal	1344 ± 36.7	1207 ± 34.7 [a]
				Animal protein: 1230 ± 35.1 kcal	975 ± 31.2	1019 ± 31.9
				Alcohol: 81±9.0 kcal	96 ± 9.8	164 ± 12.8 [b]
				Candy: 488±21.2 kcal	517 ± 22.7	517 ± 22.7
				Soda: 403.1±62 ml	572 ± 48	677.7 ± 78
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 high nutrient density and high energy density Eating episodes (total, complete meals or snacks) Energy intake (% EI) at different times of day (after 03:00, morning, afternoon or evening)	Morning (% EI)	Afternoon	Night
				Meat: 22.3 ± 1.7%	20.0 ± 1.4%	17.2 ± 1.3 % [b]
				Breads: 12.4 ± 1.2%	14.0 ± 0.6%	8.0 ± 0.9 % [a]
				Additional Fat: 5.5 ± 0.4%	5.9 ± 0.5%	7.6 ± 0.4 % [a]
				Soda: 4.7 ± 0.7%	6.7 ± 0.7%	6.9 ± 0.7 % [b]
				Fruits / Vegetables: 3.1 ± 0.5%	4.0 ± 0.9%	7.1 ± 0.9 % [a]
				Eating episodes/day: Total: 5.3 ± 0.2 % EI	5.5 ± 0.9	6.2 ± 1.2
				Energy intake per period: Overnight: 1 ± 0.5 % Morning: 28.0 ± 2.0 %	0.6 ± 0.4% 19.6 ± 2.3%	9.6 ± 1.5% [a] 13.1 ± 1.7% [b]
Balieiro 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	Day shift Servings / day	Night shift	
				Meat and eggs: 2.0 ± 0.7	2.3 ± 0.9	
				Fruits: 0.7 ± 0.9	0.9 ± 0.4	
				Inadequate intake Vegetables: 92.7%	100 %	
				Oils: 24.6%	40.7 %	
Sampedro ED et al, 2010 (51)	Fixed = day without night Rotation = Includes rotating night shift	FFQ	Adequate intake according to the Spanish Society of Community Nutrition (2004)	NS		
Rodriguez M et al, 2009 (28)	Fixed = only morning, afternoon or evening Rotating = morning, afternoon and evening on a rotating basis	FFQ	High, medium and low intake distribution according to tertiles of each food group	Fixed shift vs. rotating shift	RC (95%) Meat 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)	
Sudo N et al, 2001 (39)	Fixed = 08:30–17:45 Rotation = early morning (06:00–13:45) or afternoon / evening (13:40–22:25)	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 dinne NAR = amount consumed / RDA 100	Day shift Worked days Calories: 1954.9 ± 392 kcal PTN: 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 60.7 ± 60.0g 46.8 (37.9% 60.3%) 238.0 (195.4% 281.4%) 422.7 (295.7% 552.7%)	Turn afternoon / evening 1530.1 ± 629 54.2 ± 17.8 37.2 (52.3% 29.2%) 200.0 (163.6% 262.3%) 349 (226.7% 493.3%)
				Days off: CHO: 243.5 (190.9% 292.5%) NAR (%) Worked days Energy : 108.5 ± 24 Protein: 116.2 ± 30.1 Carbohydrate: 97.7 ± 21 Fat: 132.2 (157.7% 86.3%) Calcium: 83.3 (60.8, 108.3) Iron: 76.8 (62.5% 99.2%) NAR energy Breakfast: 24.5 ± 8.2% Dinner: 38.7 ± 12.6%	8.0 (6.7% 10.4%) 200.6 (156.9% 239.0%) 93 ± 23.2 99.5 ± 27.0 87.1 ± 23.4 105.3 (89.0% 131.0%) 77.0 (47.3; 91.7) 63.7 (54.0; 84.7) 24.3 ± 11.4 26.2 ± 15.0	7.1 (5.9% 8.3%) 180.2 (143.4% 289.9) NS 84.7 ±35.2 [c] 89.9 ± 30.0 [c] 79.9 ± 31.2 [c] 85.5 (64.3; 112.4) [c] 58.8 (38,9% 89,7%) [c] 59.0 (48.9; 69.0) [c] 11.1 ± 14.8 [d] 28.2 ± 10.3 [c]

Continued

Table 6. Continued

Study	Work shift	Dietary survey used	Information assessed eating habits	Significant results		
Vimalananda, et al, 2015 (22)	Day shift Night (0:00–08:00) 1 and 2, 3 –9, ≥10 years	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% Diet soft drinks: 2% 5th quintile consumption: FV: 20% FF: 19%	1 to 2 years 1501 25 9 2 6 1 19% 21%	3 to 9 years 1570 25 11 2 7 2 18% 21%
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 Irregular meals (yes) 37.7% Frequency of meals/day (%) 1-2 meals/day: 35.8% 3 meals/day: 54.7% Irregular: 9.4% Skip Breakfast: 26.4% Time of snacks: Morning: 11.3% Afternoon: 49.1% Late (after dinner): 30.2% Night (after 22h): 5.7% Fruits ≥1 serving/day: 62.3%	With night 86.9 56.0 20.6 23.4 40.9 4.0 23.8 22.6 44.0 54.4	No night 65.7 45.7 40.0 14.3 25.7 5.7 42.9 25.7 25.7 77
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	Night/rotating shift: 184 ± 142 1822 ± 562 OR (95% CI) - Caffeine intake (>131 mg): 1.16 (1.12–1.22) OR (95% CI) Total energy (>1715 kcal/day): 1.09 (1.04–1.13)	
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– 5:00) = 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 (MDS) 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 (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% 0,11–0.46) 232 (184- 287); β 10 (95% CI 4-17) 58 (34-96); β 8 (95% CI 3-12) 8.2 (3.7-14.8); β 0.9 (95% CI : 0.1- 1.8) 118 (78-159); β 31 (95% CI 6-56) 358 (181–580); β 56 (95% CI 10-101) 23 (11–40); β: - 0.3 (95% CI - 0.6– - 0.1) Number of nights worked/month > 5 nights / month: Energy intake:β 103 (29–176) Meat (g/day): β 12 (4–19) Cholesterol: β 15 (5–26)	

Continued

Table 6. Continued

Study	Work shift	Dietary survey used	Information assessed eating habits	Significant results		
Morikawa et al, 2008 (43)	Fixed= non-rotatating 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 RWM = work without rotating at midnight RM = Rotating work with midnight	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	RWM	RM
				20–29 years:		
				SFA: 5.9 ± 1.7% EI	6.1 ± 2.2	5.4 ± 2.1
				Calcium: 180.8 ± 85.7 mg/1000kcal	188.6 ± 70.1	161.6 ± 67.9
				Potassium: 895 ± 254 mg/1000kcal	904 ± 251	830 ± 237
				Vit.A: 314 ± 166 mg/1000kcal	336 ± 182	239 ± 142
				VitB1: 0.345 ± 0,108mg/1000kcal	0.35 ± 0.096	0.317 ± 0.096
				Milk: 27.2 ± 3.2 g/1000kcal	31.0 ± 3.2	18.5 ± 3.6
				30–39 years		Others=NS
				Energy: 2,129 ± 610kcal	2182 ± 627	2356 ± 781
				Vitamin B1: 0.328 ± 0.091	0.653 ± 0.131	0.312 ± 0.082
				40–49 years:		
				PUFA: 5.4 ± 1.7% EI	5.2 ± 1.5	5.0 ± 1.6
				Meat: 15.8 ± 2.1 g/1000kcal	18.9 ± 1.8	13.7 ± 2.2
				Oils: 8.1 ± 1.7 g/1000kcal	7.7 ± 1.6	7.0 ± 1.7
				50–59 years:		
				Energy: 2109 ± 604kcal	2,181 ± 720	2276 ± 725
				Fibers: 5.37 ± 1.62 g/1000kcal	5.06 ± 1.38	5.04 ± 1.38
				Vegetables: 35.2 ± 2.1g/1000kcal	31.8 ± 1.9	30.0 ± 1.9
Pan et al, 2011 (32)	Rotating (RT): day shift + 3 nights / mont 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 / saturated fat Consumption of food groups	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	Night shift	
				Snacks: 0.21	0.42	
				Hot meals: 0.10	0.04	
				Cold foods: 0.65	0.76	
				Hot foods: 0.36	0.23	
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	Night shift	
				% (EI)		
				Sugars: 15.5% (11.3–19,7)	16.8% (14.2-19,6)	
				Food consumed: 27.5 (21.5–30)	25 (20- 30)	
				ED: 5.52kcal/g/day (4.72–5.83)	5.73kcal/g/day (5.08-6.88)	
Lasfargues et al, 1996 (52)	Day shift = NSP Night shift = NSP	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	Night shift	
				Not eat breakfast every day:		
				Men: 25.1%	32.8	
				Not eat lunch >1 time/week:		
				Men: 3.2%; Women: 6.7%	35.3; 49.6	
				Water consumption <1 liter/day		
				Men: 68.5%; Women: 72.5%	55.9; 60.4	
				Sweet drinks> 0.5 liters/day:		
				Men: 7.6%; Women: 2.6%	12.1; 6.2	
				Dairy products (<3 times per week)		
				Men: 85.4%; Women: 78.1%	79.4; 69.9	
				Bread (> 200 g/day)		
				Men: 21%	25.7	
				Calcium (mg/day)		
				Women: 1020 ± 170	996 ± 170	

[a] Night shift differs from both groups.
[b] Night shift differs from the morning shift.
[c] Afternoon /evening shift differs from daytime workers.
[d] Afternoon/evening shifts differs from both groups.

Table 7. Summary of associations between eating habits and shift work (N=33).

	Number of studies (reference number)		
	Higher in shift workers	Higher in day/fixed workers	No significant association
Quantitative analysis			
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)	1 (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)		
Eating at night (N= 6)	5 (17, 21, 33, 41, 46)	-	1 (31)

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.

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