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The association between eating frequency with alertness and gastrointestinal complaints in nurses during the night shift

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Summary

We investigated the association of the number of eating occasions and energy intake with alertness and gastrointestinal (GI) complaints in nurses during their night shift. During this observational study we collected data on anthropometrics and demographics, eating frequency, energy intake, alertness and GI complaints in 118 healthy female nurses, aged 20 to 61 years. Nurses completed an alertness test (psychomotor vigilance task) during the night shift and a 24-hr dietary recall and a questionnaire about GI complaints after the night shift. This was repeated three times, always on the first night shift in a night shift series. The number of eating occasions during the night shift was negatively associated with reaction times ($\beta = -4.81$ ms, 95% confidence interval [CI] −9.14 to −0.48; $p = .030$), and number of lapses ($\beta = -0.04$, 95% CI −0.07 to −0.00; $p = .030$). However, the number of eating occasions was not associated with subjective alertness and GI complaints. Energy intake during the night shift was not associated with objective or subjective alertness or with GI complaints. These associations were independent of caffeine intake, age, body mass index and dependence among the repeated measurements. The present study showed that eating frequency was positively associated with objectively measured alertness levels in female nurses during the night shift. The results need to be confirmed in an intervention study, where also timing, size and composition of the meal will be taken into account. In practice, optimising nutritional guidelines on these aspects could lead to faster responses, less (medical) errors, and a better wellbeing of night shift workers.

KEYWORDS

cognitive performance, fatigue, nutrition, occupational health, psychomotor vigilance task, shift work

1 | INTRODUCTION

Hospitals provide healthcare 24 hr per day and 7 days a week. In order to facilitate continuous healthcare, healthcare workers have to work outside conventional working hours (Wong & Morra, 2011), and some of them work night shifts. In the Netherlands, ~26% of healthcare workers are regularly working night shifts (CBS, 2019). However, working night shifts is associated with increased health and safety risks and a reduced wellbeing (Akerstedt, 2003; Angerer et al., 2017; Boivin & Boudreau, 2014; Dall'Ora et al., 2016).

For instance, night shift workers have a 30% higher risk of making (medical) errors or having accidents than day shift workers (Folkard et al., 2005; Folkard & Tucker, 2003; Williamson et al., 2011). This is probably because of a mismatch with the biological clock of workers during the night shift (Boivin & Boudreau, 2014). The biological clock modulates physiological processes in the human body as a function of time and is characterised by activity during the day and inactivity during the night, a circadian rhythm. This is also reflected in the alertness levels, which are at lowest between 02:00 and 06:00 hours in the early morning (Basner & Dinges, 2011; Grant et al., 2017) and could result in shift work-related fatigue (Williamson et al., 2011). Especially tasks requiring high cognitive load or sustained attention are more prone to errors due to these lowered alertness levels (Van Dongen et al., 2011). Optimising alertness levels is therefore crucial in healthcare because patient safety could be compromised (Reddy et al., 2009).

Moreover, cognitive performance appears to be sensitive to food intake, but also depends on the time of the day (Dye & Blundell, 2002; Dye et al., 2000; Landstrom et al., 2001; Lloyd et al., 1994; Smith et al., 1991). Eating at night may further deteriorate the already low alertness levels (Grant et al., 2017; Gupta et al., 2017). However, not eating at night is associated with increased hunger and cravings for food around the circadian nadir (Grant et al., 2017). It is suggested that a small snack could ensure good alertness levels and reduce hunger during the night shift (Grant et al., 2017).

Also the digestive system follows a circadian rhythm. At night the digestive system is in a resting state and metabolic processes such as stomach and intestinal peristalsis, production of gastric juices, and insulin secretion are diminished compared to daytime (Boden et al., 1996). When working the night shift, workers redistribute their food intake from day to night (De Assis Et Al., 2003; Souza et al., 2019), while total energy intake remains the same (Bonham et al., 2016). In addition, night shift workers tend to snack more frequently instead of eating a full meal (Souza et al., 2019). As the digestive system is in a relative resting state, it is not surprising that shift workers experience gastrointestinal (GI) complaints (e.g. abdominal pain, diarrhoea and heartburn) during the night (Costa, 2010; Grant et al., 2017; Saberi & Moravveji, 2010).

To date, it is not clear what the best advice for night shift workers is with respect to eating frequency and energy intake to optimise cognitive performance and reduce GI complaints. In the present study we investigated the association of the number of eating occasions and energy intake with alertness levels and GI complaints in nurses during the night shift. The results of the present study could be used to develop nutrition intervention strategies and inform dietary guidelines that can be applied as a vital part of occupational health and safety management programmes in shift work.

2 | METHODS

2.1 | Participants

Nurses working the night shift were recruited in three hospitals located in the area surrounding Wageningen, the Netherlands. Nurses were invited to participate via e-mail and advertisements posted at the intranet site for employees of the relevant hospital. To obtain a homogenous study population, nurses were included in the study when they were working the night shift for ≥6 months, were not using drugs that could cause or reduce sleep problems, were not using daylight lamps in the workplace during the night shift, were eating according to a Dutch eating pattern (two cold meals and one hot meal), and were not donating blood 1 week before and during the data collection period as donating blood could cause fatigue (Kiss & Vassallo, 2018). In total, we screened and included 164 nurses, aged 18–61 years, of whom 24 dropped out of the study before data on dietary intake was collected. We additionally excluded 11 male nurses, and eight smokers and three nurses with missing data on smoking from the data analysis, as they formed a minority of the study population and could affect the study results. Male nurses, for example, had a different eating pattern than female nurses, and smokers were exposed to fresh air during the night shift during their cigarette breaks, which could have affected the psychomotor vigilance task (PVT) results. Sample size calculations were performed on the parameter dietary intake in order to obtain a reliable estimate of the usual dietary intake, where energy and all macro- and micronutrients were covered. It allowed us to detect differences among dietary intake and to perform subgroup analysis. All nurses gave written consent before the start of the study.

2.2 | Study design

This observational study was conducted between April 2015 and July 2018. At the start of the data collection period, nurses had their height and body weight measured, and they completed a demographic questionnaire. Thereafter, based on night shift timetables, measurements in nurses were scheduled and nurses were asked to complete an alertness test once between 02:00 and 05:00 hours during the night shift. At 17:00 hours the same day, nurses were invited via email to complete a 24-hr dietary recall and a questionnaire including questions about quality and duration of day sleep, and GI complaints during that night shift. We always measured the first night shift in a series of night shifts, and this was repeated over three series of night shifts with at least 1 month in between. A night shift series was defined as a row of consecutive night shifts. The study was approved by the Medical Ethical Committee of Wageningen University and Research (ABR: NL54414.081.15) and was conducted according to the principles of the Declaration of Helsinki.

2.3 | Anthropometrics and demographics

Height was measured without shoes using a stadiometer to the nearest 0.5 cm. Body weight was measured without shoes to the nearest 0.5 kg using analogue, or to the nearest 0.1 kg using digital weighing scales, depending on the hospital. Height and body weight were used to calculate body mass index (BMI) in kg/m^2. The demographic questionnaire included questions about e.g. education, smoking, and working hours.

2.4 | Dietary intake

Dietary intake was assessed by three 24-hr dietary recalls. Each 24-hr dietary recall was completed on the day after the first night shift. The 24-hr dietary recalls were self-administered via Compl-eat, a web-based program. Compl-eat is based on a validated technique to increase the accuracy of dietary recalls (Conway et al., 2003), and includes foods used in a Dutch food pattern (van Rossum et al., 2011). Portion sizes of foods or recipes were reported by using household measures, standard portion sizes, or weights in grammes. Nurses were asked to record all the foods and drinks they consumed during 24 hr; from the evening meal prior to the night shift until the evening meal after the night shift. They were also asked to write down the time of day when each food or drink was consumed. All foods and drinks reported at one moment in time were considered as the intake of one eating occasion. An eating occasion was defined as a new eating occasion if it was at least 15 min apart from the previous one (Leech et al., 2015). For the eating occasions count, we excluded all eating occasions where only drinks were consumed to avoid over-estimation of the total number of eating occasions (Aljuraiban et al., 2015). Average daily energy intake per night shift and average energy intake per eating occasion were calculated by first multiplying the frequency of each food or drink by portion size and energy content using the 2013 Dutch Food Composition Table (Dutch Institute and for Public Health and the Environment, 2013) Thereafter, we calculated energy intake per eating occasion, per night shift and total daily energy intake by adding up the energy intake of each food and drink. Drinks were included in the caffeine and energy intake calculations. All intakes reported between the start and the end time of the night shift was classified as consumption during the night shift.

2.5 | Objective and subjective alertness

Objective alertness was assessed by the PVT. The PVT is a validated 10-min visual reaction time task that evaluates sustained attention (Basner & Dinges, 2011). This task was carried out on a desktop computer between 02:00 and 05:00 hours during the night shift. Nurses were asked to respond to the appearance of a visual stimulus, a white circle on a black screen, by pressing the space bar as quickly as possible. The visual stimulus appeared every 2–10 s for 10 min at a fixed point on the screen. When nurses were interrupted while performing the PVT, either by a patient or a colleague, they were asked to take the PVT again. For each completed PVT, we determined the median reaction time (RT; ms), mean reciprocal response time (1/RT), and number of lapses (RT >500 ms). As the number of lapses were not normally distributed, we used log transformation for the number of lapses and added one lapse to compensate for the nurses that had no lapses (log[number of lapses + 1]).

Subjective alertness was assessed by the 7-point Samn–Perelli Scale (SPS). Nurses were asked to complete the SPS before the start of the PVT. The SPS asks the level of fatigue at that moment. The answer scores range from 1 (“fully alert, wide awake”) to 7 (“completely exhausted, unable to function effectively”) (Samn and Perelli, 1982).

2.6 | Gastrointestinal complaints

Gastrointestinal complaints were assessed using a five-item self-rating questionnaire. Each item was scored using a 5 point Likert-type rating scale. The score of each item was summed up to get a total GI complaint score (five items; $\alpha = 0.842$). GI complaints included: gastric pain, diarrhoea/constipation, growling intestines, heartburn, and bloating. The answer scores ranged from 1 (“completely disagree”) to 5 (“completely agree”).

2.7 | Statistical analysis

All analyses were performed in SPSS statistics, version 25. A $p < .05$ was considered statistically significant. Raw data were checked for quality (outliers, omissions) and normality. Data are presented in mean (± *SD*), in *n* (%) or as median and interquartile range (IQR) in case of skewness. Differences in subjective and objective alertness over the three non-consecutive night shifts were assessed by a Wilcoxon rank test. Pearson correlations were used to investigate the correlation between subjective alertness and reciprocal reaction time and log transformed number of lapses. To analyse the association between the number of eating occasions (i.e. eating frequency) or energy intake with alertness during the night shift, we used linear mixed models with alertness as dependent variable (objective and subjective measures separately) and additionally adjusting for eating frequency or total energy intake, respectively, in kcal during the night shift, and for caffeine, age, and BMI. We also controlled for dependence amongst the repeated measurements for each nurse and controlled for cluster effects within the three hospitals. To analyse the association between the number of eating occasions or energy intake during the night shift and GI complaints we used similar linear mixed models with total score for GI complaints or the separate GI complaints as dependent variable and adjusted for the same variables. When outliers were present, we performed the analysis with and without the outliers. If an outlier did not result in different associations and conclusions, we kept the outlier in the analysis.

3 | RESULTS

3.1 | Participant characteristics

About half (55.1%) of the nurses were classified as having normal body weight and 44.0% as being overweight or obese (Table 1). Body weight remained stable throughout the data collection period. The start time of the night shift was between 22:00 and 23:15 hours and the night shift started at mean (*SD*) of 22:54 hours (23 min). The end time of the night shift was between 07:00 and 08:30 hours and ended at a mean (*SD*) of 07:26 hours (17 min). Nurses worked on mean (*SD*) of 2.6 (2.0) night shifts series/month and 2.6 (1.0) night shifts/series. This means that nurses worked on a mean (*SD*) of 6.4 (5.0) night shifts each month. This number differed significantly between the three hospitals. Anthropometric and demographic data did not differ significantly between the hospitals.

3.2 | Subjective and objective alertness

The PVT was started a mean (*SD*) of 03:09 hours (48 min). Nurses had a median (IQR) reaction time of 414.4 (382.5–463.1) ms (Figure 1), a mean (*SD*) reciprocal reaction time of 2.52 (0.32) ms and median (IQR) 9.8 (4.3–19.4) lapses (Figure 2) on the PVT during the night shifts. They scored mean (*SD*) of 3.2 (0.8) out of a score of 7 on the SPS, which is considered as 'Okay, somewhat fresh' (Samn and Perelli, 1982). The subjective and objective alertness levels did not differ significantly between the three study periods. Subjective alertness was not correlated with reciprocal reaction time ($r = -0.107$, $p = .320$) or the number of lapses ($r = 0.136$, $p = .143$).

TABLE 1 Anthropometrics and demographics of female night shift working nurses ($n = 118$) in mean (*SD*), median (IQR) or *n* (%)

Characteristic	Value
Age, years, median (IQR)	44.2 (30.1–51.6)
Body weight, kg, mean (*SD*)	71.9 (12.88)
Height, cm, mean (*SD*)	169.3 (5.87)
Body mass index, kg/m^2, mean (*SD*)	25.0 (4.10)
Underweight (<18 kg/m^2), *n* (%)	1 (0.8)
Normal (18–25 kg/m^2), *n* (%)	65 (55.1)
Overweight (25–30 kg/m^2), *n* (%)	43 (36.4)
Obese (>30 kg/m^2), *n* (%)	9 (7.6)
Education *n* (%)	
Intermediate education,	61 (51.7)
Higher education	55 (46.6)
Married/cohabiting, *n* (%)	
Yes	98 (83.1)
Children, *n* (%)	
Yes	64 (54.2)
Employment/week, hr, mean (*SD*)	28.4 (5.71)
Night shifts series/month, series, mean (*SD*)	2.6 (1.98)
Night shifts/series, nights, mean (*SD*)	2.6 (0.97)
Night shift experience, years, mean (*SD*)	17.5 (11.62)

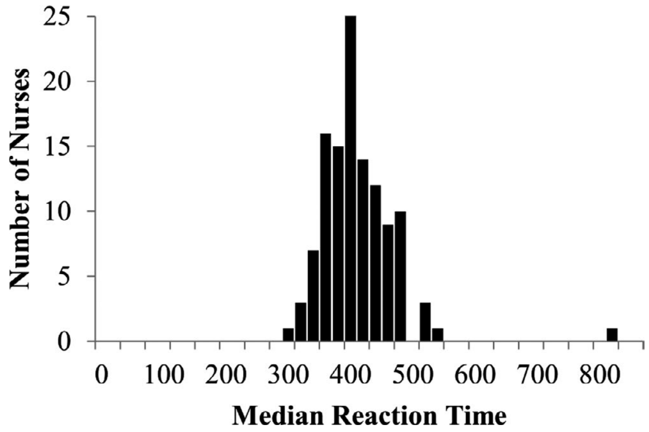

FIGURE 1 Histogram of average median reaction time (ms) of nurses ($n = 118$)

3.3 | Gastrointestinal complaints

A total of 79.0% of the nurses experienced at least one GI complaint during one of the night shifts. The most prevalent GI complaints nurses reported were growling intestines and bloating. Growling intestines was experienced during 54.0% of the night shifts and bloating during 45.7% of all night shifts. Diarrhoea or constipation was experienced during 23.3%, gastric pain during 11.0%, and heartburn during 8.6% of the night shifts. In 22.4% of the cases at least three GI complaints were experienced to a greater or lesser extent during the same night shift.

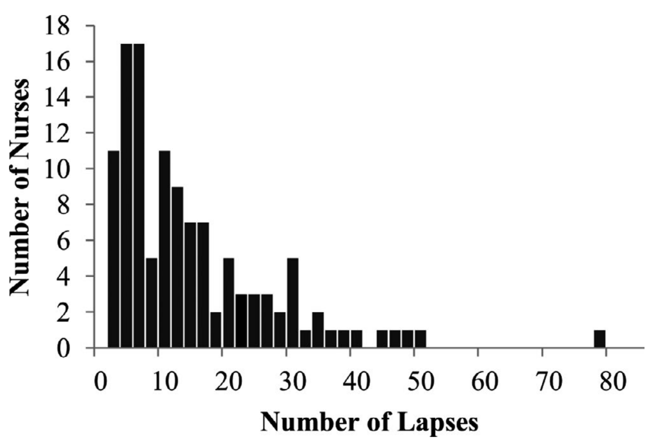

FIGURE 2 Histogram of average number of lapses of nurses ($n = 118$)

3.4 | Dietary intake

All included nurses completed at least one 24-hr dietary recall. Seven nurses completed only one 24-hr recall, 14 nurses completed two 24-hr recalls, and 97 nurses completed all three 24-hr recalls. Foods and drinks were consumed throughout the day (Figure 3). All nurses consumed foods or drinks during the night shift.

The nurses had on average 6.0 (IQR 5.0–7.3) eating occasions between the evening meal prior to the night shift until the evening meal after the night of which 2.5 (IQR 2.0–3.0) eating occasions were during the night shift. They consumed a mean (*SD*) of 1656 (450) kcal between the evening meal prior to the night shift until the evening meal after the night, of which 610 (IQR 455–737) kcal were consumed during the night shift. An eating occasion during the night shift consisted on average of 175 (IQR 82–343) kcal. The nurses consumed on average 37.3 (IQR 0.0–100.5) mg caffeine during the night shift. This corresponds to one cup of green or black tea or half a cup of coffee.

3.5 | Eating frequency, energy intake and alertness

Table 2 shows the associations of number of eating occasions and total energy intake during the night shift with objective and subjective alertness. The number of eating occasions was positively associated with alertness levels. This was shown by the number of eating occasions that was inversely associated with median reaction time (β = −4.81 ms, 95% confidence interval [CI] −9.14 to −0.48; *p* = .030), and log transformed number of lapses (β = −0.04, 95% CI −0.07 to −0.00; *p* = .030), and was positively associated with reciprocal reaction time (β = −0.03 1/ms, 95% CI 0.00 to 0.05; *p* = .018). Total energy intake during the night shift was not associated with alertness levels. The number of eating occasions, as well as energy intake, was not associated with subjective alertness. More caffeine was associated with slower reaction times and deteriorated subjective alertness levels, but not with more lapses. Age was associated with deteriorated subjective alertness levels.

3.6 | Eating frequency, energy intake and GI complaints

The number of eating occasions was not associated with the total GI complaints score (β = −0.13, 95% CI −0.51 to 0.25; *p* = .493) (Table 3). However, when looking at the separate GI complaints, the number of eating occasions was associated with less heartburn (β = −0.11, 95% CI −0.19 to −0.02; *p* = .017), and not with any of the other single complaints. Total energy intake (per 100 kcal) during the night shift was not associated with the total GI complaints score (β = −0.12, 95% CI −0.27 to 0.02; *p* = .099).

Older age was associated with less total GI complaints (β = −0.02, 95% CI −0.03 to 0.00; *p* = .048), i.e. less constipation/diarrhoea and growling intestines. Caffeine use was associated with more heartburn and bloating but not with gastric pain, constipation/diarrhoea or growling intestines.

4 | DISCUSSION

The present study examined the association of the number of eating occasions and energy intake with objective and subjective alertness and GI complaints in female nurses during the night shift. We showed that more eating occasions during the night shift was associated with faster reaction times and fewer lapses (delayed reaction

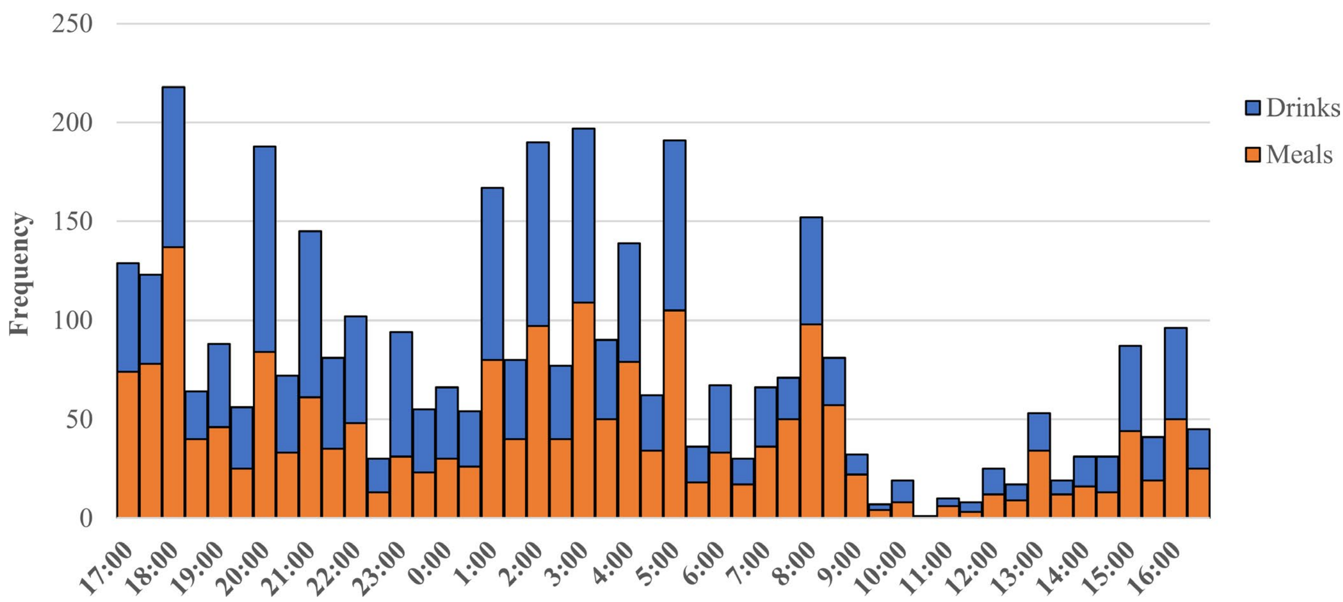

FIGURE 3 Distribution of meals and drinks consumed by nurses (*n* = 118) before, during and after the night shift, measured by three 24-hr dietary recalls

TABLE 2 Association between number of eating occasions and energy intake with objective and subjective alertness in 118 female nurses during the night shift

	Median[a]/mean[b]	(IQR)/±SD	Median reaction time (ms)			Reciprocal reaction time (1/ms)			Number of lapses (log)			Samn–Perelli Scale		
			β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*
Number of EO	2.5[a]	(2.0–3.0)	−4.81	(−9.14 to −0.48)	.030	0.03	(0.00 to 0.05)	.018	−0.04	(−0.07 to −0.00)	.030	−0.01	(−0.11 to 0.08)	.779
Energy per 100 kcal	609.8[a]	(454.6–736.5)	1.43	(−0.19 to 3.06)	.084	−0.01	(−0.01 to 0.00)	.233	0.00	(−0.01 to 0.02)	.575	−0.02	(−0.06 to 0.02)	.291
Caffeine per 100 mg	37.3[a]	(0.0–100.5)	8.78	(3.53 to 14.03)	.001	−0.04	(−0.07 to −0.01)	.004	0.02	(−0.02 to 0.07)	.354	0.16	(0.04 to 0.29)	.008
Age, years	44.2[a]	(30.1–51.6)	0.20	(−0.63 to 1.02)	.639	0.00	(−0.00 to 0.00)	.996	0.00	(−0.01 to 0.00)	.438	−0.01	(−0.02 to 0.00)	.027
BMI, kg/m2	25.0[b]	±4.1	0.86	(−1.50 to 3.22)	.472	−0.01	(−0.02 to 0.01)	.386	0.00	(−0.01 to 0.02)	.681	−0.01	(−0.04 to 0.03)	.746

BMI, body mass index; EO, eating occasions; IQR, interquartile range.

[a]Median is provided when data was not normally distributed.

[b]Mean is provided when data was normally distributed.

time >500 ms). However, the number of eating occasions was not associated with subjective alertness or GI complaints. Also, total energy intake during the night shift was not associated with both objective and subjective alertness and GI complaints.

To our knowledge the present study is the first to investigate the association between the number of eating occasions with objective and subjective alertness and GI complaints in nurses during a night shift in a real-life setting. Our present finding that more eating occasions during the night shift was associated with faster reaction times and fewer lapses gives additional insight to the findings of other studies. Earlier studies focussed on the difference between eating either a small or large meal or not eating at all (Grant et al., 2017; Gupta et al., 2017, 2019a). These studies found that eating one large meal resulted in a worsening of objective alertness levels during the circadian nadir (Grant et al., 2017; Gupta et al., 2017, 2019a) and a small snack resulted in the best objective alertness levels during a sustained driving task (Gupta et al., 2019a). They also suggested that other options, such as eating multiple snacks or eating a snack later during the night shift, could improve alertness levels and should be investigated as hunger feelings are especially present at the end of the night shift. As our present study had an observational study design, it allowed us to investigate the number of eating occasions. Although total energy intake during the night shift in our present study was comparable with that provided by the large meals in the studies of Grant et al. and Gupta et al. (Grant et al., 2017; Gupta et al., 2017, 2019a), the amount was distributed over several eating occasions. Hence, our present results support their hypothesis that smaller meals could prevent deterioration in alertness levels.

Our present study did not find an association between subjective alertness and the number of eating events. Similar results were found in the studies of Grant et al., (2017) and Gupta et al., (2017, 2019a, 2019b). They did not find differences in subjective alertness of their participants in eating a large meal versus eating no meal during the night (Grant et al., 2017; Gupta et al., 2017, 2019a, 2019b). Interestingly, Gupta et al. (2019) found that eating a small meal, however, led to the best subjective alertness levels (Gupta et al., 2019a, 2019b). The exact mechanism behind it is not yet clear. Eating at night is used by some night shift workers as one of the strategies to keep alert during the night (Bonham et al., 2016; Gupta et al., et al., 2019; Sagah Zadeh et al., 2018). It is shown that the immediate effect of consuming food seems to reduce sleepiness (Landstrom et al., 2001). However, this effect seems to disappear after half an hour. This could explain why we, but also Grant et al. (2017) and Gupta et al. (2019a), did not find differences in subjective alertness between a large meal and no meal as we did not investigate immediate effects. However, it does not explain why a small meal would result in the best subjective alertness compared to a large meal during the night shift at around 04:00 hours. It is suggested that subjective alertness over-estimates actual objective measures of alertness (Wilson et al., 2019; Zhou et al., 2012). Furthermore, differences found in subjective alertness during sleep deprivation, as happens during a night shift, are expected to be smaller than differences in objective alertness compared to a non-sleep deprived state

TABLE 3 Association between number of eating occasions and energy intake with total score of gastrointestinal complaints in 118 female nurses during the night shift

Variable	Median[a]/ mean[b]	(IQR)/ ±*SD*	Gastrointestinal complaints β	95% CI	*p*
Number of EO	2.5[a]	(2.0–3.0)	−0.13	(−0.51 to 0.25)	.493
Energy per 100 kcal	609.8[a]	(454.6–736.5)	−0.12	(−0.27 to 0.02)	.099
Caffeine per 100 mg	37.3[a]	(0.0–100.5)	0.28	(−0.2 to 0.76)	.251
Age, years	44.2[a]	(30.1–51.6)	−0.08	(−0.14 to −0.01)	.019
BMI, kg/m^2	25.0[b]	±4.1	0.04	(−0.14 to 0.22)	.678

BMI, body mass index; EO, eating occasions; IQR, interquartile range.

[a]Median is provided when data was not normally distributed.

[b]Mean is provided when data was normally distributed.

(Zhou et al., 2012). This could be another explanation why we did not find explicit differences in subjective alertness when we analysed the association between subjective alertness and the number of eating occasions. In addition, sleep before the night shift may have influenced subjective alertness and dietary intake. Nurses could have had a poor night's sleep prior to the first night shift or could have taken a nap. Although we observed that half of the nurses took a nap prior to the night shift, we do not know when they took a nap or how they slept the night prior to the first night shift. Although associations between diet and subjective alertness are not evident, it might still be useful to include these measurements. Improving subjective alertness can be seen as a perceivable benefit that consequently could lead to higher motivation to comply with a dietary intervention. Nevertheless, better and more sensitive methods are needed to assess subjective alertness, specifically over a longer time period.

For GI complaints, we observed an association between the numbers of eating occasions with heartburn but not with the total score of GI complaints, which was unexpected. It was hypothesised that more eating occasions would have been associated with relative more GI complaints, as the digestive system is in a relative resting state during the night. More eating occasions were expected to disrupt this resting state. However, it could be that eating at night results in different types of GI complaints compared to not eating at night. In the study of Grant et al. (2017), not eating at night resulted in increased stomach upset, especially around 04:00 hours (Grant et al., 2017). This was not the case in the eating at night group. On the other hand, eating at night resulted in increased bloating compared to not eating at night (Grant et al., 2017). Additionally, a small meal resulted in fewer complaints. As in our present study population every nurse consumed some food to a greater or lesser extent, we cannot draw any conclusions on whether not eating is associated with less GI complaints compared to eating.

However, we found an association between caffeine use and heartburn and bloating, and an association between age and constipation/diarrhoea and growling intestine. These results suggest that other factors, such as caffeine intake and age, are involved as well. It is suggested that caffeine contributes to the development of GI complaints (Lowden et al., 2010); however, there is no clear evidence available in literature. For age it is likely that nurses who experience less GI complaints will work the night shift at a later age than nurses with complaints. Moreover, other studies found associations between GI complaints and sleep disturbances (Hyun et al., 2019; Zhou et al., 2017). However, these studies were cross-sectional and therefore causal relationships could not be assessed. In addition, sleep disturbances could also be related to changed meal times or the other way around and not necessarily directly to the GI complaints. Sleep disturbances were not taken into account in the present study.

The present study has several strengths. It has a relatively large sample size and included multiple measurements per nurse, which increases the power. We included nurses from three different hospitals, increasing the external validity to other female health professionals. However, these results cannot be generalised to other night shift working populations, because the type of work might affect alertness levels. In addition, other night shift working populations may have different dietary intake patterns that can influence alertness levels, as well as the prevalence and extent of GI complaints. Also, we only included women in the data analysis because the number of men was rather low and could bias the results. The studies of Grant et al. (2017) included men only, because the menstrual cycle and oral contraceptives of women could influence the results of the PVT (Vidafar et al., 2018; Wright & Badia, 1999). We did not collect data on the phase of the menstrual cycle of the nurses or contraceptives, and therefore could not analyse the influence of hormonal changes.

Although the observational study design allowed us to investigate multiple dietary factors that could affect objective and subjective alertness and GI complaints, we cannot draw any conclusions about the causal relationships between the found associations in the present study. We also have to interpret the results with caution as the found regression coefficients are rather small. Another limitation related to the observational design is that we observed a large variation in the amount of energy per eating occasion that nurses consumed during the night shift. Therefore, it was not possible to draw conclusions about the size of an eating occasion in relation to alertness levels. Although the results showed that more eating occasions are associated with better objective alertness, it is hypothesised that the consumption of only one or more small meals during the night shift could further improve alertness levels and probably decrease the experienced GI complaints during the night shift (Grant et al., 2017). However, this should be further investigated (Gupta et al., 2019a, 2019b).

In conclusion, the present study showed that eating frequency is positively associated with objective alertness levels in female nurses during the night shift. The results need to be confirmed in an intervention study, where also the timing, size and composition of the meal are taken into account. In practice, optimising nutritional guidelines in terms of timing, frequency, size and composition of a meal could lead to faster responses, less (medical) errors, and a better wellbeing of night shift workers.

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CONFLICT OF INTERESTS

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AUTHOR CONTRIBUTIONS

MR, JV, AE, and EK designed the study (project conception, development of overall study plan). MR conducted the research with help from WW, TH and CL. MR did the data analysis. MR, JV, SB and EF wrote the manuscript. All authors read and approved the final version of the manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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