

The effectiveness of healthy meals at work on reaction time, mood and dietary intake: a randomised cross-over study in daytime and shift workers at an university hospital

Eva Leedo^{1*}, Anne Marie Beck^{1,2}, Arne Astrup^{1,3} and Anne D. Lassen⁴

¹Clinical Nutrition Research Unit, Copenhagen University Hospital Herlev-Gentofte, Ledreborg Allé 38, opgang 20A, DK-2820 Gentofte, Denmark

²Department of Nutrition and Health, Metropolitan University College, Pustervig 8, DK-1126 Copenhagen K, Denmark

³Department of Nutrition, Exercise and Sports, University of Copenhagen, Nørre Allé 51, DK-2200 Copenhagen N, Denmark

⁴Division for Risk Assessment and Nutrition, National Food Institute, Technical University of Denmark, Mørkhøj Bygade 19, DK-2860 Søborg, Denmark

(Submitted 7 December 2016 – Final revision received 12 June 2017 – Accepted 29 June 2017)

Abstract

Our dietary habits affect both cognitive performance and mood. The aim of the study was to examine the effect of increased availability of healthy meals and water at work on healthcare staff. The study used an 8-week randomised cross-over design. A total of sixty physicians, nurses and nursing assistants, including sixteen working on shifts, were recruited. The participants received a self-selected keyhole-labelled (Nordic nutrition label) lunch, snack and bottled water during each shift throughout the intervention period. Reaction time (Go/No-Go test), mood-related scores (POMS) and dietary intake were assessed at run-in, and at the end of the intervention and the control periods. The intake of fat ($P=0.030$) and PUFA ($P=0.003$) was lower, and the intake of carbohydrate ($P=0.008$), dietary fibre ($P=0.031$) and water ($P<0.001$) was greater in the intervention period than in the control period. The intervention had no effect on reaction time or any of the mood-related scores in the group as a whole. In shift-working participants, the intervention period resulted in a 31.1% lower Fatigue-Inertia Score ($P=0.003$), a 15.3% higher Vigour-Activity Score ($P=0.041$) and a 42.7% lower Total Mood Disturbance Score ($P=0.017$), whereas the only dietary component that significantly improved was water intake ($P=0.034$), when compared with the control period. Providing healthy meals, snacks and water during working hours seems to be an effective way of improving employees' dietary intake. Moreover, increased intake of water may be associated with beneficial effects on fatigue, vigour and total mood in shift-working healthcare staff.

Key words: Workplace nutrition: Reaction time: Mood: Healthcare staff: Shift workers

In recent years, there has been a growing interest in how our dietary habits affect cognitive performance and mood^(1,2). A healthy diet, including a high consumption of fruit and vegetables, fatty fish and nuts, and a low intake of SFA, has been associated with cognitive benefits in children, old adults and in midlife^(3–6). Conversely, skipping meals or eating sugary snacks can result in low blood glucose levels, causing slowed reaction time, lowered concentration and mood^(7–9).

A previous study demonstrated that healthcare staff often eat unhealthily or skip meals because of limited time to take a break, as well as limited access to healthy meals and snacks⁽¹⁰⁾. This was supported by an employee survey at the Copenhagen University Hospital Herlev-Gentofte in Denmark, where stated reasons for non-users of the staff canteen were both limited canteen opening hours and lack of time and opportunity to leave the ward⁽¹¹⁾. A high proportion of the staff participating in the survey responded that they would make use of vending machines with healthy snacks, if available⁽¹¹⁾. It is generally

acknowledged that there is an abundance of chocolate on hospital wards, rather than access to healthy meals or snacks, as chocolate is often given to hospital staff by patients as a token of their gratitude⁽¹²⁾. Moreover, a prospective cohort study by El-Sharkawy *et al.*⁽¹³⁾ among nurses and physicians highlighted that a significant proportion of nurses and physicians were dehydrated at the start and end of medical and surgical shifts. Dehydration was associated with some impairment of cognitive function.

The observed lack of access to proper meals and beverages at work among healthcare personnel may have implication not only in a health promotion perspective but also in terms of reaction time and, ultimately, in patient security. Night-shift workers typically have the most limited opportunities to leave the ward and most limited access to canteen services or other meal options. Nabe-Nielsen *et al.*⁽¹⁴⁾ showed in a cross-sectional questionnaire study that working environment interventions in the eldercare sector may reach shift workers to a lower extent

* Corresponding author: E. Leedo, email evaleedo@hotmail.com

compared with fixed day workers. This group of employees has also been associated with more unfavourable dietary habits compared with day workers⁽¹⁵⁾. Also, there is some preliminary evidence that shift work may adversely influence cognitive functions. Titova *et al.*⁽¹⁶⁾ observed that current and recent former shift workers performed worse on a trailmaking test, which measures executive cognitive function, compared with non-shift workers.

As far as we know, research examining the effect of optimal workday nutrition on cognitive function in healthcare staff is limited to a study by Lemaire *et al.*⁽¹⁷⁾. They demonstrated a positive effect of offering healthy food on physicians' cognitive score, reaction time and blood glucose levels. The study was relatively small (twenty participants) and the intervention only lasted 1 d. For the majority of the participants (seventeen of twenty) the study took place during the day.

A review by Schröer *et al.*⁽¹⁸⁾ concluded that employees' dietary behaviour can be influenced by workplace interventions based solely on nutritional education or in combination with environmental modifications. They point out that maintaining employees' health and work performance, including introduction of workplace health promotion and prevention programmes, is of great importance. However, there is still a lack of sufficient evidence through randomised controlled trials on effective and feasible strategies to promote healthy eating among healthcare staff, including workers on shift schedules.

The objective of the present study was to examine the effectiveness of increased availability of healthy meals at work, including a cold lunch meal, bottled water and a snack, on reaction time, mood and total dietary intake among hospital healthcare staff. We further aimed to conduct a subgroup analysis examining data separately for the participants working on shift schedules.

Methods

Study design

The study used an 8-week randomised cross-over design, initiated with a 1-week run-in period (Fig. 1). Participants were divided into fifteen groups, with four participants in each, according to the sequence of recruitment. All participants entered the study simultaneously. The number of participants allocated to each group was because of practical reasons, as there was only capacity to test four participants a day. The groups were block-randomised to start either with the intervention period or the control period. The randomisation process was carried out by an independent research assistant drawing lots from several small closed labels

with 'control' or 'intervention' written on them. The subjects were informed about their allocation before the start of the study.

Each subject was required to attend three test sessions: on the 1st day of run-in period, on the last day of the control period and on the last day of the intervention period, respectively. The tests were completed under standardised conditions – that is in the same location and at the same time in the morning after the subjects ate their habitual breakfast. Consumption of coffee and other drinks high in caffeine, for example, black tea, was not allowed 10 h before the tests.

Participant recruitment

Physicians, nurses and nursing assistants employed at the Copenhagen University Hospital in Herlev-Gentofte in Denmark were recruited for the study through posters displayed around the hospital, and through advertisements on the hospital Intranet in August 2012. Approximately 130 persons attended information meetings, ninety-six were selected for screening and sixty were enrolled as study participants. Screening and enrolment was performed by one of three research assistants. Exclusion criteria were BMI below 18.5 or above 35 kg/m², use of staff canteen more than once a week, weekly working hours below 30, no direct contact with patients, food allergy or intolerance, pregnancy, extreme level of physical activity and vacation of more than 1 week during the study period. The study period ran from September until December 2012.

Participants were classified as shift workers if the majority of their working hours were in the evening, at night and/or at the weekend.

Ethical statement

All subjects signed a written consent after receiving oral and written information about the study. Because of the design of the study, no approval was needed from the Research Ethics Committee according to the Danish law. The study was registered at ClinicalTrials.gov, identifier: NCT01739569.

Intervention content

During the intervention period the participants were offered a cold meal, a bottle of water and a snack on all workdays/shifts. Two cold meals, two snacks and two bottles of water were delivered for participants working a double shift. No educational activities or recommendations were made regarding dietary intake. In the control period the participants were instructed to continue with their habitual dietary intake. Both groups were asked to maintain their body weight and their habitual level of physical activity throughout the study period.

The cold meals were pre-packed lunch meals selected from the ordinary Keyhole menu at the hospital staff canteen. The Keyhole is a Nordic nutrition label designed to make it easier for customers to choose healthier food alternatives. Meals eligible to carry the Keyhole label must fulfil certain conditions, including appropriate portion sizes, a maximum amount of fat, salt and sugar and a minimum amount of dietary fibre, whole grain, fruit and vegetables⁽¹⁹⁾. Each weekday the participants could choose

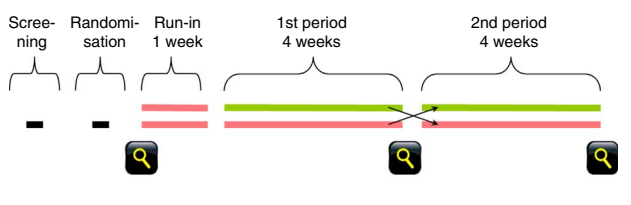


Fig. 1. The diagram of the study design. —, Intervention diet; —, habitual diet; 🔍, assessment of reaction time, mood, dietary intake.

between six different Keyhole cold meals – that is three salads, two closed sandwiches and one open rye sandwich. The selection of cold lunch meals changed according to availability at the weekend. There was a total of seventy-six different keyhole-labelled cold lunch meals in the selection during the whole study period.

The snacks were designed especially for the present study based on results from a focus group session with a total of nine healthcare employees conducted at the hospital before the beginning of the study. They were further designed so that they could be eaten 'on the go', and to have an energy content of 800–1000 kJ corresponding to about 10% of the recommended total daily energy intake for adults⁽²⁰⁾. The snacks consisted of three elements: a fresh in-house-baked bun or an in-house-produced muesli bar, a piece of fresh fruit and a bottle of water (500 ml). There were seven different buns or muesli bars in rotation: a rye bun with dark chocolate or dates on Monday and Thursday, a wheat bun with spinach/feta cheese or potato/pesto on Tuesday and Friday and a muesli bar on Wednesday. At weekends the same bun as delivered on Friday was generally supplied. The type of fresh fruit provided changed according to availability.

All subjects had to provide a working plan for the intervention period in order for the study to provide a proper service. Moreover, participants had to order the cold meals by 12.00 hours on Friday the week before delivery at the latest. A salad meal and the days' snack were delivered to the participant as a default, if they failed to place an order on schedule. The food was delivered to the respective wards between 11.00 and 12.00 hours on weekdays and between 14.00 and 16.00 hours the Friday before for weekend shifts.

The nutrient composition of the intervention meals is described in Table 1. The average serving size of the cold meals was 366 (SD 85.7) g and that of the offered snacks was 63 (SD 19.3) g.

Anthropometrics

Body weight was measured using the same body composition analyser TBF-300 (TANITA), in the same location, and standardised to the nearest 0.1 kg, ensuring that participants voided their bladder immediately before weighing, and that clothing

was the same each time (i.e. no coat, no shoes, empty pockets, phones removed). BMI was calculated using the measured weight and self-reported height.

Reaction time test

Reaction time was measured by Go/No-Go test from the Test-battery for Attentional Performance version 2.1⁽²¹⁾. This task tested the participants' ability to perform under time pressure while suppressing inappropriate behaviour responses⁽²²⁾.

Go/No-Go is a complex reaction time test of 2 min 45 s, where five different patterned squares appear randomly one-by-one on the computer screen. Two of these squares are defined as target stimuli, upon the appearance of which the subject should react as quickly as possible with a key press; no reaction is required to the other squares. The trial number is sixty, of which twenty-four are targets and thirty-six distractors. Average reaction time (ms) for correct responses and number of errors and omissions were recorded. In this study, the sum of errors and omissions is presented as 'Errors'.

Mood-related measures

The Profile of Mood States (POMS) questionnaire was used to assess participants' subjective mood state. The questionnaire consists of sixty-five mood-related adjectives, of which the subjects are asked to state their experience over the past week on a five-point scale from 0 (not at all) to 4 (extremely)⁽²³⁾. Items are summarised in six factors: Tension-Anxiety, Confusion-Bewilderment, Anger-Hostility, Depression-Dejection, Fatigue-Inertia and Vigour-Activity. A total mood disturbance score is the sum of the first five factors minus Vigour-Activity Score. High scores indicate greater mood disturbance on all scales except Vigour-Activity.

Dietary intake record

Subjects completed 4-d self-reported dietary records to provide information about their dietary intake during the study. This was done during the run-in week, and during the last week of both the intervention and the control periods. The subjects were instructed in dietary recording during the run-in meeting, and were asked to record quantities and items of all foods and drinks consumed. The dietary recordings had to be performed in concordance with participants' working schedule, so the recordings reflected intake during workdays. The participants were given feedback and advice after delivering the first dietary record on how they could complete it even more comprehensively. Dietary intake on days when only a partial recording was completed was not included in the analyses. A research assistant blinded to the result of the randomisation manually entered the dietary records using MADLOG VITA[®] software (based on data from www.frida.fooddata.dk).

Power calculations

The power calculations of the total group of participants were based on the primary endpoint, reaction time and were based

Table 1. Nutrient composition of the meals offered in the intervention period (Mean values and standard deviations)

	Cold meal*		Snack†	
	Mean	SD	Mean	SD
Energy (kJ/meal)	1736.8	427.0	942.8	261.2
Fat (E%/meal)	26.3	8.0	18.6	14.7
SFA (g/meal)	3.2	2.3	1.5	1.0
PUFA (g/meal)	0.5	0.5	0.1	0.1
Protein (E%/meal)	20.4	6.8	7.5	3.6
Carbohydrate (E%/meal)	53.3	8.7	73.9	16.2
Dietary fibre (g/meal)	8.5	2.9	4.7	0.9
Water (ml/meal)	262.5	87.2	114.4	43.6

E%, energy percentage.

* The values are means of all seventy-six keyhole-labelled lunch meals served during the whole study period.

† The values are means of all seven buns/muesli bars and eight different fruits served during the whole study period.

on a study by Jakobsen *et al.*⁽²⁴⁾, in which a positive effect of a high-protein diet on reaction time was reported. With a power of 0.9, an $\alpha=0.05$, a $\delta=-25.5$ and an SD 40, a sample size of fifty-four was required. A total of sixty participants were included in the study in order to allow for possible dropouts.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 19.0. Initially a possible existence of a carryover effect of treatment sequence on all outcomes was examined. Mean difference between absolute values at the end of each period was tested for normality and compared with each other. When data were normally distributed, a Students' *t* test was used to compare values between the periods. For Depression-Dejection Score, number of errors in reaction time test and intake of SFA, PUFA and water, data were not normally distributed and the non-parametric equivalent (Mann-Whitney *U* test) was used to compare the absolute values at the end of the periods. Normally distributed data are presented as means and standard deviations, whereas data not normally distributed are presented as medians and ranges. All statistical tests and *P* values were two-sided and a cut-off level of $P<0.05$ was used for assessing statistical significance. Data analysis was made both on the total group and on a subgroup of the participants working shift schedules ($n=16$); however, these groups were not compared with each other.

Results

Sixty subjects entered the study. One subject dropped out during the first period because of long-term sick leave and was not included in the analysis. The run-in characteristics of the fifty-nine study participants are listed in Table 2.

The mean values of all variables after the two periods, and the mean differences between the periods, are presented in Table 3. The participants were weight-stable throughout the whole period.

No significant difference in reaction time or number of errors in the reaction time test was observed between the intervention and the control period. Likewise, the subgroup analysis in the participating shift workers ($n=16$) showed no differences in either reaction time or in number of errors in the reaction time test between the intervention and the control period (Table 4).

Differences between mean values of the mood-related scores did not reach the level of significance in the group as a whole (Table 3). In contrast, several significant beneficial differences in the mood-related scores were seen among the participating shift workers (Table 4, Fig. 2). The intervention period resulted in a 31.1% lower Fatigue-Inertia Score ($P=0.003$), a 15.3% higher Vigour-Activity Score ($P=0.041$) and a 42.7% lower Total Mood Disturbance Score ($P=0.017$) compared with the control period. Moreover, a trend for shift-working participants to feel less confused ($P=0.070$) and angry ($P=0.084$) was observed.

Several differences in daily dietary intake were seen between the study periods in the group as a whole. The intake of fat ($P=0.030$) and PUFA ($P=0.003$) was lower, and the intake of

carbohydrate ($P=0.008$), dietary fibre ($P=0.031$) and water ($P<0.001$) was greater in the intervention period than in the control period. No differences were observed in energy, SFA or protein intake (Table 3).

The intervention period resulted in a significantly higher intake of water compared with the control period among shift workers (Table 4). None of the other dietary components reached a significant difference between the periods, although the same tendencies were observed as in the whole study group.

Discussion

In this randomised, cross-over design study the effectiveness of increased availability of healthy cold meals, water and snacks at work on participants' reaction time, mood and dietary intake was examined in a group of sixty healthcare staff. A subgroup analysis was made on the sixteen participating employees working shifts. The study found a beneficial effect on dietary intake for the group as a whole (Table 3), and a beneficial effect on several mood-related parameters for participating shift workers (Table 4, Fig. 2). However, no effect on reaction time was found in either the whole group or in the shift-work subgroup.

Effect on dietary intake

This study providing healthy foods and snacks, as well as bottled water, at work was an effective way of both improving employees' dietary intake (e.g. a lower total fat and a higher fibre intake) and increasing their water intake on working days.

Similar effects were seen in a short-term 2-d cross-over study⁽¹⁷⁾ in physicians, which found that higher intake of nutrients and improved hydration could be reached by providing healthy meals and beverages during work. The authors also concluded that implementing a nutritional intervention in a healthcare system is feasible on a practical level. Sharma *et al.*⁽²⁵⁾ conducted a cross-sectional analysis describing current policies and practices targeting the nutrition and physical environment in five large hospitals. They emphasised the need of environmental and policy-based strategies to successfully improve healthy nutrition and/or physical activity among employees, including making healthy snacks readily available (e.g. in vending machine and break rooms) especially for the night-shift workers who often do not have access to canteens⁽²⁵⁾.

Torquati *et al.*⁽²⁶⁾ conducted a systematic review on the effectiveness of intervention studies promoting diet and physical activity in nurses. They found that dietary outcomes were generally positive, although studies in this area were very limited. The positive effect found in this study on food intake is supported by other 'real-life' intervention studies among other employee groups using environmental strategies for improving employees' dietary intake – that is canteen takeaway⁽²⁷⁾, fruit schemes⁽²⁸⁾ and offering healthy canteen food^(19,29).

Reaction time

The lack of observed statistically significant effect of the intervention on reaction time is in discordance with the findings



Table 2. Run-in characteristics of the study participants (*n* 59)
(Numbers and percentages; mean values and standard deviations; medians and ranges)

	<i>n</i>		%	
Sex (<i>n</i>)				
Male	7		12	
Female	52		88	
Profession (<i>n</i>)				
Physician	11		19	
Nurse	43		73	
Nursing assistant	5		8	
Working schedule (<i>n</i>)				
Daytime workers	43		73	
Shift workers	16		27	
	The group as a whole		Shift workers	
	Mean	SD	Mean	SD
Age (years)	45.1	9.3	40.9	10.5
Body weight (kg)	70.4	10.6	76.2	12.3
BMI (kg/m ²)	24.1	3.5	24.8	3.9
Go/No-Go				
Reaction time (ms)	559.6	60.8	542.6	66.9
No. of errors				
Median		1.0		0.0
Range		0.0–22.0		0.0–22.0
Profile of mood states				
Tension-Anxiety Score	5.2	3.5	5.7	4.4
Depression-Dejection Score				
Median		3.0		4.0
Range		0–21		0.0–18.0
Anger-Hostility Score	5.7	4.2	6.6	3.6
Fatigue-Inertia Score	6.6	4.5	8.6	4.7
Confusion-Bewilderment Score	4.3	3.0	5.9	3.0
Vigour-Activity Score	19.3	4.5	18.8	4.0
Total Mood Disturbance Score	6.4	18.6	13.1	18.7
Dietary intake				
Energy (kJ/d)	8096.4	1452.1	7246.8	888.7
Fat (E%)	30.4	4.9	30.1	4.5
SFA (E%)				
Median		20.3		17.8
Range		9.7–35.0		11.4–26.3
PUFA (g)				
Median		1.5		1.3
Range		0.5–5.6		0.7–5.6
Protein (E%)	16.3	2.4	17.1	3.0
Carbohydrate (E%)	53.2	5.2	53.0	4.9
Dietary fibre (g/d)	26.0	5.8	25.2	5.4
Water, incl. from food (ml/d)				
Median		2273.5		2188.9
Range		1068.3–4926.3		1068.3–4352.3

E%, energy percentage.

of a previous intervention study, in which the effect of increased availability of healthy meals was examined in physicians⁽¹⁷⁾. Results from this smaller and shorter term study suggested a significant improvement in reaction time when healthy meals were provided for 1 d. Although the study by Lemaire *et al.*⁽¹⁷⁾ also used a cross-over design, the study used a different method to assess reaction time than the present study. In a similar study in young males, in which all foods were provided for 3 weeks and reaction time was measured using the same method as in the present study, a significant positive effect of the diet on reaction time was seen⁽²⁴⁾. However, this study investigated the effect of a high-protein diet, which was not the focus of the current study. Moreover, the results from the study by Jacobsen and co-authors might not be fully comparable to ours, as 88% of the subjects in

the current study were females, who have shown to have slightly longer reaction time compared with males⁽³⁰⁾, and because our baseline reaction time was approximately 100 ms higher compared with the baseline reaction time in their study. One of the explanations for the somewhat surprising lack of effect on reaction time and mood could be the fact that the study population was relatively healthy at the beginning of the study. The intake of total fat, carbohydrates, protein and dietary fibre, except for SFA, all met Nordic Nutrition Recommendation 2012 reference ranges for intake⁽²⁰⁾. Another explanation could be that a large part of our study population was made up of nurses who worked at outpatient clinics. The hospital outpatient clinics usually have regular opening hours and planned breaks, giving a good opportunity to take time off for both lunch and coffee

Table 3. Reaction time, mood-related scores and dietary variables and differences between the mean values after the intervention and control period for the group as a whole (*n* 59)
(Mean values and standard deviations; mean values and 95% confidence intervals)

	Intervention		Control		Intervention v. control		<i>P</i>
	Mean	SD	Mean	SD	Mean	95% CI	
Weight (kg)	70.3	10.8	70.3	11.0	0.1	-0.1, 0.3	0.461
Go/No-Go							
Reaction time (ms)	543.5	57.7	540.7	54.3	2.8	-7.3, 13.0	0.581
No. of errors					-0.3	-0.9, 0.3	0.724
Median	0.0		0.0				
Range	0.0-11.0		0.0-17.0				
Profile of Mood States Scores							
Tension-Anxiety	4.9	3.6	4.7	2.8	0.2	-0.6, 1.0	0.575
Depression-Dejection					-0.3	-1.3, 0.8	0.462
Median	2.0		2.0				
Range	0.0-31.0		0.0-37.0				
Anger-Hostility	5.1	4.5	5.7	4.7	-0.6	-1.7, 0.5	0.316
Fatigue-Inertia	6.0	5.0	6.8	5.1	-0.9	-1.8, 0.1	0.081
Confusion-Bewilderment	3.6	3.1	4.1	2.8	-0.4	-1.0, 0.1	0.129
Vigour-Activity	19.6	6.0	18.6	5.3	1.0	-0.2, 2.2	0.094
Total Mood Disturbance	3.8	22.3	6.8	19.8	-2.9	-6.3, 0.5	0.091
Daily dietary intake							
Total energy (kJ/d)	7508.1	1292.5	7525.5	1616.8	-17.4	-500.2, 465.4	0.943
Fat (E%)	28.6	4.7	30.4	5.1	-1.8	-3.4, -0.2	0.030
SFA (E%)					0.3	-2.1, 2.7	0.830
Median	16.0		15.8				
Range	7.4-39.5		7.3-33.5				
PUFA (g/d)					-0.5	-0.8, -0.2	0.003
Median	1.4		1.7				
Range	0.5-4.1		0.4-5.2				
Protein (E%)	17.0	2.0	17.2	2.8	-0.2	-1.0, 0.6	0.591
Carbohydrate (E%)	54.4	5.0	52.0	5.3	2.4	0.6, 4.2	0.008
Dietary fibre (g/d)	25.0	6.0	23.1	7.0	1.9	0.2, 3.6	0.031
Water, incl. from food (ml/d)					240.7	117.4, 363.9	0.000
Median	2321.0		1917.8				
Range	704.3-4642.8		656.0-4251.0				

E%, energy percentage.

Table 4. Reaction time, mood-related scores and dietary variables and differences between the mean values after the intervention and control period for the shift workers (*n* 16)
(Mean values and standard deviations; mean values and 95% confidence intervals)

	Intervention		Control		Intervention v. control		<i>P</i>
	Mean	SD	Mean	SD	Mean	95% CI	
Weight (kg)	76.5	12.6	76.3	12.4	0.2	-0.3, 0.6	0.495
Go/No-Go							
Reaction time (ms)	528.3	56.2	519.4	50.3	8.9	-8.1, 25.9	0.284
No. of errors					-1.2	-3.5, 1.1	0.301
Median	0.0		0.0				
Range	0.0-2.0		0.0-17.0				
Profile of Mood States Scores							
Tension-Anxiety	5.1	3.2	4.9	2.6	0.2	-1.1, 1.5	0.762
Depression-Dejection					-1.3	-4.0, 1.3	0.207
Median	2.5		4.0				
Range	0.0-22.0		0.0-37.0				
Anger-Hostility	5.4	4.0	6.4	4.5	-1.0	-2.2, 0.2	0.084
Fatigue-Inertia	5.8	3.7	8.4	4.5	-2.6	-4.2, -1.1	0.003
Confusion-Bewilderment	4.4	3.4	5.4	2.6	-1.1	-2.2, 0.1	0.070
Vigour-Activity	19.3	4.7	16.8	5.2	2.6	0.1, 5.0	0.041
Total Mood Disturbance	6.3	19.9	14.6	20.6	-8.4	-15.0, -1.7	0.017
Daily dietary intake							
Total energy (kJ/d)	7503.0	1312.5	7187.2	1284.8	315.8	-458.7, 1090.3	0.398
Fat (E%)	28.7	4.5	30.8	4.9	-2.1	-1.6, 1.1	0.177
SFA (E%)					0.0	-3.4, 3.4	0.623
Median	16.4		14.0				
Range	8.7-24.3		7.3-28.3				
PUFA (g/d)					-0.3	-1.0, 0.4	0.215
Median	1.3		1.3				
Range	0.5-4.1		0.5-3.8				
Protein (E%)	16.9	1.7	17.2	2.2	-0.3	-1.6, 1.1	0.650
Carbohydrate (E%)	54.5	5.3	50.6	5.4	3.9	-0.6, 8.3	0.085
Dietary fibre (g/d)	24.0	4.7	22.7	6.8	1.3	-2.3, 4.8	0.465
Water, incl. from food (ml/d)					311.9	35.9, 587.9	0.034
Median	2360.6		2143.9				
Range	704.3-4642.8		656.0-4009.0				

E%, energy percentage.

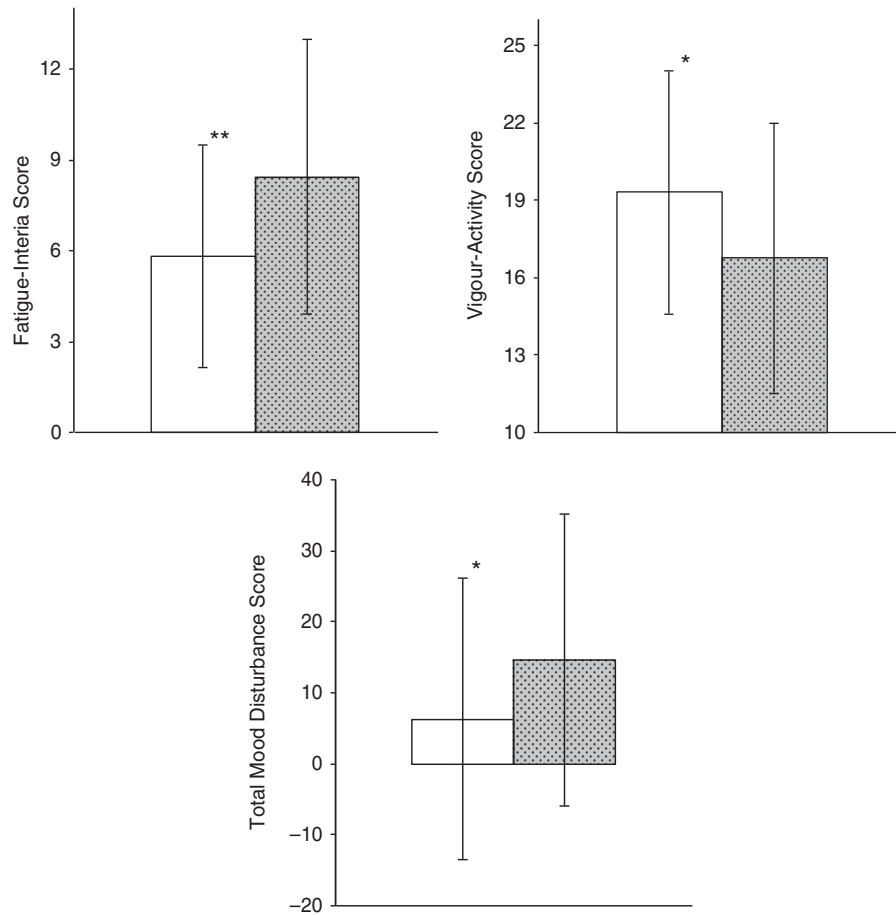


Fig. 2. Scores of Fatigue-Inertia, Vigour-Activity and Total Mood Disturbance in shift workers after intervention (□) and control (▨) period. Values are means, and standard deviations represented by vertical bars. Statistical differences are based on Students' *t* test. Significantly different from the control period: * $P < 0.05$; ** $P < 0.005$.

breaks. In addition, 88% of this study population comprised women, who are generally known to be more health conscious and have healthier eating habits than men⁽³⁰⁾.

Mood-related scores

As far as we know, this study is the first to examine cognitive response in healthy subjects to an increased accessibility to cold meals, water and snacks, at work over a longer period of time. Although no significant effect was observed on the group as a whole, improved mood scores, Fatigue-Inertia, Vigour-Activity and Total Mood Disturbance, and a trend towards lower Anger-Hostility and Confusion-Bewilderment were observed in shift workers, who significantly improved their intake of water during the intervention period.

Our findings are partially supported by the results of a short-term study by Montain *et al.*⁽³¹⁾, who found that providing healthy foods as eat-on-the-move rations for shift-working firefighters resulted in less depression and confusion ratings on the POMS scale.

Strengths and limitations

A major strength of our study was the cross-over design, which reduced the influence of confounding covariates, as participants

served as their own controls. Furthermore, the study had a very low dropout rate (2%). Finally, the study was performed in free-living environment of the participants, which increases the external validity of our findings. It suggests practical solutions to meal provision to more effectively target factors promoting employees' health and performance in the long term.

Some limitations must also be addressed. First, the subjects were not asked to perform any intervention compliance check. Thus, for all outcome measures, the lack of intervention effects can in part be attributed to the level of compliance to the programme – that is the proportion of meals actually consumed. Second, power calculation was performed on the primary outcome reaction time for the whole group. A retrospective power calculation on reaction time for the subgroup of shift workers ($n = 16$) showed a power of only 0.4 based on the study by Jakobsen *et al.*⁽²⁴⁾. Consequently, the results of the subgroup analysis should be interpreted with sample size as an acknowledged limitation. A retrospective power calculation on the mood outcome Fatigue-Inertia revealed that a difference of 2.2 would be detectable for the group as a whole based on a study by Montain *et al.*⁽³¹⁾ ($P = 0.05$, $SD = 4.2$, $power = 0.8$). Another limitation was that there was no washout period between the two periods. However, a washout period is often unnecessary if the second period is long enough to allow the carryover effect to diminish.

Participation was voluntary, giving rise to a possible self-selection bias. Employees participating in health promotion studies may be more health conscious than other employees, and therefore not representative of the general employee group. This was confirmed by a healthier dietary intake profile at run-in compared with the average Danish population. A final limitation of the study is that dietary intake findings, as well as mood-related outcomes, are based on self-reported information, which could create response bias.

The study has highlighted the need for putting the work meal and drink, especially at shift work, on the agenda. The results are promising, but more research is needed on the effectiveness, changes in both intake and cognitive function, and feasibility of intervention studies under free-living conditions.

Conclusion

This study providing healthy meals, snacks and water during working hours was an effective way of improving employees' dietary intake during working days, which may have long-term health benefits. Moreover, in the shorter term, the intervention resulted in an increased intake of water and beneficial mood changes in shift workers. In the present study, no significant differences in reaction time was found. The novel finding of potential beneficial effects of water on mood-related parameters in shift workers requires additional investigation. More well-powered randomised controlled trials including a greater proportion of men working shifts are needed to confirm these findings.

Acknowledgements

The authors thank Katrine Rask and Annette Vedelsvang for the practical help during the study period, Heidi Anker for processing the dietary data, Michael Allerup Nielsen for securing funding and support in completion of the study, Christian Bitz for scientific support and Tobias Wrenfeldt Klausen for statistical advice.

The study was funded by The Nordic Kitchen at the Copenhagen University Hospital Herlev-Gentofte. The Nordic Kitchen had no influence on the design of the study, the manuscript or its conclusions.

The authors' responsibilities were as follows – E. L.: participated in the research design, conducted the research, analysed the data, wrote the manuscript and had primary responsibility for the final content; A. M. B.: designed the research; A. M. B., A. A. and A. D. L.: collaborated on writing the manuscript; A. D. L.: participated in the research design. All authors approve the final version of the manuscript.

The authors declare that there are no conflicts of interest.

References

- Hammersley R, Reid M & Atkin SL (2014) How to measure mood in nutrition research. *Nutr Res Rev* **27**, 284–294.
- Jager CA, Dye L, Bruin EA, *et al.* (2014) Criteria for validation and selection of cognitive tests for investigating the effects of foods and nutrients. *Nutr Rev* **72**, 162–179.
- Lampert DJ, Saunders C, Butler LT, *et al.* (2014) Fruits, vegetables, 100% juices, and cognitive function. *Nutr Rev* **72**, 774–789.
- McMillan L, Owen L, Kras M, *et al.* (2011) Behavioural effects of a 10-day Mediterranean diet. Results from a pilot study evaluating mood and cognitive performance. *Appetite* **56**, 143–147.
- Muldoon MF, Ryan CM, Yao JK, *et al.* (2014) Long-chain omega-3 fatty acids and optimization of cognitive performance. *Mil Med* **179**, 95–105.
- Pribis P, Bailey RN, Russell AA, *et al.* (2012) Effects of walnut consumption on cognitive performance in young adults. *Br J Nutr* **107**, 1393–1401.
- Hoyland A, Lawton CL & Dye L (2008) Acute effects of macronutrient manipulations on cognitive test performance in healthy young adults: a systematic research review. *Neurosci Biobehav R* **32**, 72–85.
- Mueller K, Libuda L, Terschluesen AM, *et al.* (2013) A review of the effects of lunch on adults' short-term cognitive functioning. *Can J Diet Pract Res* **74**, 181–188.
- Muff C, Reinhardt JD, Erbel R, *et al.* (2011) Who is at risk of irregular meal intake? Results from a population-based study. *J Public Health* **19**, 453–462.
- Lemaire JB, Wallace JE, Dinsmore K, *et al.* (2011) Food for thought: an exploratory study of how physicians experience poor workplace nutrition. *Nutr J* **10**, 18.
- Copenhagen University Hospital Herlev (2010) *User Satisfaction Survey. Internal Report*. Herlev, Denmark: Copenhagen University Hospital Herlev.
- Cheung ST (2003) The effects of chocolates given by patients on the well-being of nurses and their support staff. *Nutr Health* **17**, 65–69.
- El-Sharkawy AM, Bragg D, Watson P, *et al.* (2016) Hydration amongst nurses and doctors on-call (the HANDS on prospective cohort study). *Clin Nutr* **35**, 935–942.
- Nabe-Nielsen K, Jorgensen MB, Garde AH, *et al.* (2016) Do working environment interventions reach shift workers? *Int Arch Occup Environ Health* **89**, 163–170.
- Hemio K, Puttonen S, Viitasalo K, *et al.* (2015) Food and nutrient intake among workers with different shift systems. *Occup Environ Med* **72**, 513–520.
- Titova OE, Lindberg E, Elmstahl S, *et al.* (2016) Association between shift work history and performance on the trail making test in middle-aged and elderly humans: the EpiHealth study. *Neurobiol Aging* **45**, 23–29.
- Lemaire JB, Wallace JE, Dinsmore K, *et al.* (2010) Physician nutrition and cognition during work hours: effect of a nutrition based intervention. *BMC Health Serv Res* **10**, 241.
- Schröer S, Haupt J & Pieper C (2014) Evidence-based lifestyle interventions in the workplace-an overview. *Occup Med (Lond)* **64**, 8–12.
- Lassen AD, Beck A, Leedo E, *et al.* (2014) Effectiveness of offering healthy labelled meals in improving the nutritional quality of lunch meals eaten in a worksite canteen. *Appetite* **75**, 128–134.
- Nordic Council of Ministers (2014) *Nordic Nutrition Recommendations 2012. Integrating Nutrition and Physical Activity*, 5th ed. Nord 2014:002. Copenhagen: Nordic Council of Ministers.
- Zimmermann P & Fimm B (2007) *Test of Attentional Performance. Version 2.1 [User Manual]*. Herzogenrath, Germany: Psychologische Testsysteme. www.psytest.net
- Sorensen JM (2011) Framework for developing functional foods for patients at nutritional risk. PhD Thesis: University of Copenhagen.
- McNair DM & Heuchert JWP (2011) *Profile of Mood States [User Manual]*. London: MHS Assessments.
- Jakobsen LH, Kondrup J, Zellner M, *et al.* (2011) Effect of a high protein meat diet on muscle and cognitive functions: A randomised controlled dietary intervention trial in healthy men. *Clin Nutr* **30**, 303–311.





25. Sharma SV, Paolicelli CW, Jyothi V, *et al.* (2016) Evaluation of worksite policies and practices promoting nutrition and physical activity among hospital workers. *Int J Workplace Health Manag* **9**, 46–62.
26. Torquati L, Pavey T, Kolbe-Alexander T, *et al.* (2017) Promoting diet and physical activity in nurses: a systematic review. *Am J Health Promot* **31**, 19–27.
27. Lassen AD (2010) Healthy eating at worksites – effectiveness of a Canteen Take Away concept in promoting healthy eating among employees. PhD Thesis, Søborg: Technical University of Denmark, National Food Institute.
28. Alinia S, Lassen AD, Krogsholm KS, *et al.* (2011) A workplace feasibility study of the effect of a minimal fruit intervention on fruit and nutrient intake. *Public Health Nutr* **14**, 1382–1387.
29. Lassen AD, Thorsen AV, Sommer HM, *et al.* (2011) Improving the diet of employees at blue-collar worksites: results from the ‘Food at Work’ intervention study. *Public Health Nutr* **14**, 965–974.
30. Lassen AD, Lehmann C, Andersen EW, *et al.* (2016) Gender differences in purchase intentions and reasons for meal selection among fast food customers. Opportunities for healthier and more sustainable fast food. *Food Qual Prefer* **47**, 123–129.
31. Montain SJ, Baker-Fulco CJ, Niro PJ, *et al.* (2008) Efficacy of eat-on-move ration for sustaining physical activity, reaction time, and mood. *Med Sci Sports Exerc* **40**, 1970–1976.