Experimental manipulation of breakfast in normal and overweight/obese participants is associated with changes to nutrient and energy intake consumption patterns

Authors:

Sue Reeves[a], Jörg W Huber[b], Lewis G Halsey[a], Yasmin Horabady-Farahani[a], Mehrnaz Ijadi[a] and Tina Smith[c]

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Corresponding author: Dr Sue Reeves[a]
Email: s.reeves@roehampton.ac.uk
Telephone: 0044 (0)208 392 3228
Fax: 0208 392 3610

[a]Department of Life Sciences
University of Roehampton University
Holybourne Avenue
London SW15 4JD
UK

[b]Centre for Health & Wellbeing Research
University of Northampton
Boughton Green Road
Northampton
NN2 7AL
UK

[c]Department of Sport, Health & Exercise Science
University of Hull
Cottingham Road
HU6 7RX
UK

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Abstract

The effect of breakfast and breakfast omission on daily food intake in normal and overweight participants was investigated. 37 participants were recruited for this experimental study and assigned to one of four groups on the basis of their body mass index (BMI) (normal weight BMI <25 kg/m^2 or overweight/obese BMI > 25 kg/m^2) and habitual breakfast habits (breakfast eater or breakfast omitter). All participants were requested to eat breakfast for an entire week, and then following a washout period, omit breakfast for an entire week, or vice versa. Seven-day food diaries reporting what was consumed and the timing of consumption were completed for each breakfast condition. Overall more energy was consumed during the breakfast than the no breakfast condition. The present study revealed significant effects of timing on energy intakes; more energy was consumed during the afternoon in the no breakfast condition compared to the breakfast condition. Overweight participants consumed greater amounts of energy than normal weight participants early evening. Breakfast omitters consumed more than breakfast eaters later in the evening. All groups consumed significantly less energy, carbohydrate and fibre in the no breakfast condition however overweight participants increased their sugar intakes. Consumption of the micronutrients iron and folate was reduced in the no breakfast condition. The findings highlight that the timing of food intake and habitual breakfast eating behaviour are important factors when investigating why breakfast consumption may be associated with BMI.

Keywords: Breakfast; Timing; Obesity; Ingestion.

1. Introduction

Food intake has been described as a rhythmic behaviour that is com- prised of episodes of eating interspersed with periods of fasting [11]. This rhythm of eating has been demonstrated to be both circadian and ultraradian (e.g. meal to meal), in animals and humans in both laboratory and free-living situations [10,19,35,36]. Recently, a number of studies have shown that the timing of food intake may affect the amount consumed and be linked to weight gain and obesity [1,21,24]. Higher energy intakes in the morning are correlated with lower energy intakes over the entire day [12], but some studies have shown that even when energy intakes are similar, people who consume more of those calories later in the day tend to put on more weight [21]. In a study of 156 females and 863 males aged 21–69 years, participants who consumed more than a third of their daily energy intake in the evening were twice as likely to be overweight or obese [44]. Similarly in a study of French children aged 7–12 years who were grouped according to their BMI classification there were no differences in energy intake between groups. However, there were differences in the timing and distribution of the food intakes. Obese children generally ate less at breakfast and more at dinner than leaner children and consumed a greater proportion of their energy as fat at lunch and dinner. It was concluded that disturbed metabolic and or behaviour circadian rhythms may contribute to weight gain [6]. Therefore if people who eat more of their daily energy intakes in the morning are less likely to be overweight or obese then this may be one of the reasons why people who eat breakfast tend to be slimmer than people who omit breakfast [14,15]. However results from various breakfast studies investigating energy intake in adults and children are conflicting; some demonstrating that eating breakfast influences total daily food intakes by actually increasing energy intake [28,41] whereas other studies report no effect on energy intakes [9,43].

The role that routine plays in daily food intakes is also an important consideration, since many people habitually eat or omit breakfast. In a study conducted by Schlundt et al. [39] investigating obese women wanting to lose weight, half of the participants were assigned a diet where they maintained their usual routine of either eating or omitting breakfast. The remaining participants were asked to switch regime i.e. breakfast eaters omitted breakfast and breakfast omitters consumed breakfast. Participants who had switched their usual morning routine, regardless of whether that constituted eating or omitting breakfast, lost the greatest amounts of weight. However, eating regularity may also be a feature of routine food intakes and Farshchi et al. [17] have shown that in healthy obese women regular eating is associated with lower energy intakes, as well as being beneficial in terms of fasting lipid and post-prandial insulin profiles. Furthermore in a study of healthy lean women following a prescribed irregular meal pattern, it was shown that even when total food intake data was not directly affected, sporadic food intakes may have influenced post-prandial energy expenditure, and in that way impact upon long term weight gain [18]. There are few studies that distinguish differences in food daily intake patterns between genders; in a study of spontaneous human feeding patterns there was no relationship with gender and meal pattern other than males tended to eat significantly larger meals [13]. Changes in sleep patterns also illustrate how routine affects food intakes; in a study of 12 men who underwent sleep restriction it was found that there was increased hunger and food intake the day after sleep restriction [8], and altered sleep–wake routines generally disrupting normal feeding patterns [35]. It has also been reported that 'evening types' i.e. people who prefer to be active later in the day or during the night have a higher propensity to put on weight and less ability to lose weight than 'morning types' (early risers) [23].

Given the suggested circadian and routine nature of food intakes this study aims to investigate the effect of breakfast and breakfast omission on food intake but also the timing of subsequent food intakes. By recruiting participants with different BMIs and breakfast habits, this will allow assessment of the effect of breakfast on daily food intake in normal and overweight/obese participants, and habitual breakfast eaters and breakfast omitters.

2. Methods

2.1 Participants

Sixteen male and twenty one female adult participants (n= 37) were recruited from the University of Roehampton and the Greater London area. Ethical approval was obtained from the University of Roehampton Ethics Committee. All interested participants were asked to read an information sheet and if they were agreeable sign a participant consent form. Exclusion criteria included dieting, diabetes, symptoms such as dizziness, fainting and blackouts, high blood pressure or cholesterol medication. The participants were assigned to one of four groups according to their BMI and normal habitual breakfast habit. Two groups were made up of participants with BMIs under 25 kg/m^2 (18.3 to 24.5 kg/m^2), described as normal weight, and two other groups were composed of participants with BMI over 25 kg/m^2 (25.4 to 48.0 kg/m^2), comprising overweight and obese participants; hereafter referred to as overweight. One of the normal weight groups and one of the overweight groups comprised habitual breakfast eaters whereas the other normal weight group and overweight group comprised habitual breakfast omitters. Verbal information on usual breakfast habit was collected upon recruitment. A breakfast eater was classified as someone who normally ate breakfast (at least 100 kcal from food) more than 5 days a week, a breakfast omitter only ate breakfast on two or fewer occasions per week. Participants who did not fall neatly into either breakfast category were excluded at recruitment (6 participants were excluded on this basis). Participant characteristics are provided in table 1.

Table 1.

Description of participants

About here

Regardless of breakfast habit all participants were requested to eat breakfast for an entire week (breakfast condition) and omit breakfast for an entire week (no breakfast condition); the order was assigned randomly. There was a minimum of a one week wash-out period between breakfast conditions. In menstruating women, each breakfast condition was started at the same point in their cycles.

2.2 Food Intake measurements

Seven-day food diaries were completed by the participants in each breakfast condition. The participants were provided with verbal and written instructions on how to complete the diaries. Participants were asked to carry the diaries with them at all times, recording everything they consumed including drinks. Details about the type and brand of the items consumed, how they were prepared, as well as the quantities, were reported. The diaries also contained descriptions and photos to depict typical medium sized portions of a range of foods to aid accurate reporting of the amounts consumed. The food diaries were analysed using Dietplan 6 (Forestfield Software, Horsham, UK) and estimates of nutrient and energy intake (kcal) per day were calculated. Energy intake was further analysed for intake per hour of the day, where a 'day' was defined to start at 06:00 h and end at 05:59 h such that eating after midnight but prior to typical waking hours was included as part of the intake of the previous calendar day.

2.3 Data analysis

The data were collated using Excel (version 2003 Microsoft Corp. Redmond, USA) and SPSS (version 17; SPSS. Chicago, USA) was used for statistical analysis. All data are reported as the mean ± SD. Data were checked for violation of normality assumptions prior to statistical analysis; equality of variances was assessed using Levene's test. Food intake data were statistically analysed using a repeated measures 3-way ANOVA to examine the effects of condition, BMI and breakfast habit. One-sample t-tests were used to compare mean daily intake of calcium and folate for breakfast and no breakfast conditions against the reference nutrient intake (RNI) for the United Kingdom. To analyse the timing of mean energy intake following the experimental intervention, 12-noon to 24 h midnight was divided into four 3 hour periods starting at 12:00 h, 15:00 h, 18:00 h and 21:00 h. ANOVA was used to examine the effects of experimental breakfast condition, time-period, BMI and breakfast habit on energy intake. Evidence for statistical significance was deemed strong when $p \leq 0.05$; Bonferroni adjustment was applied to multiple (more than two) dependent comparisons.

3. Results

3.1 Energy intake and its timing

Energy intake data is presented as the total daily intake as well as totals for hourly and 3-hourly periods from 12:00 noon onwards. More energy was consumed per day during the breakfast condition compared to the no breakfast condition across all participant groups (1948 ± 488 kcal vs 1788 ± 516 kcal; $F_{1,33} = 5.13$, $p = 0.03$). Neither BMI nor breakfast habit influenced energy intake (F-values < 1.0; p-values > 0.50), but there was some evidence for an interaction between condition and BMI.

There were no differences in energy intakes between normal and overweight individuals in either breakfast condition ($F_{1,33}$ = 2.18; p = 0.15). The possibility of a sequence effect, i.e. a systematic change of energy intake from week 1 to week 2 independent of experimental intervention was tested, but was found not to be significant (t_{36} = 0.89; p = 0.38).

To explore the link between breakfast condition and weight, hourly energy intake figures for breakfast and no breakfast are presented, with participants grouped into normal weight (Figure 1a) and overweight (Figure 1b) respectively. The figures confirm the fidelity of the conditions in that very little energy was consumed during the no breakfast condition (white coloured bars) during the morning hours. A surge in energy intake can be observed in the figures after 12:00 noon when participants were permitted to eat.

Figure 1 a & b

Hourly energy intakes

About here (to be printed side by side)

Statistical analysis of the data presented in figure 1 a & b focused on the period post noon until 24:00 hours midnight, after which energy intake was very low. For data analytic purposes this time period was divided into four 3-hour periods, starting at 12:00 noon, 15:00 h etc. Repeated measures analysis of variance with breakfast condition (2 levels) and time periods (4 levels) was carried out; weight and breakfast habit, as before, were entered as between subject factors. This analysis confirmed the strong effect of experimental condition ($F_{1,33}$=7.94; p = 0.008) with lower energy consumption during the no breakfast condition; there was little evidence of a 2-way interaction between condition and BMI ($F_{1,33}$= 2.94; p = 0.096). The main effect of the factor time period was highly significant as expected ($F_{1,31}$= 22.1; $p < 0.0005$). However, the time period factor did not interact with BMI ($F_{1,31}$=0.15; p = 0.70), but with breakfast habit ($F_{1,31}$=6.9; p = 0.013). No other main effects or interactions reached significance.

On the basis of the highly significant main effect of time period, the four time periods were analysed separately using repeated measures ANOVA with breakfast condition as a single repeated measures factor, and weight and breakfast habit as between subject factors. For the first time period (12:00 noon -15:00 h), breakfast condition was highly significant associated with participants consuming more energy in the no breakfast condition ($F_{1,33}$=7.67; p = 0.009), but interactions with BMI ($F_{1,33}$=1.32; p = 0.26) and breakfast habit ($F_{1,33}$=3.36; p = 0.08) did not reach significance. During the late afternoon period (15:00 – 18:00 h) more energy was consumed during the no breakfast condition (267 ± 160 vs. 208 ± 138kcal; $F_{1,33}$=4.42; p = 0.043); no other main effect or interaction reached significance (all F-values ≤ 2.0; p-values > 0.15). During the early evening (18:00 – 21:00 h) BMI had a significant effect on energy intake with the overweight group consuming more (637 ± 219 vs. 450 ± 162 kcal; $F_{1,33}$=8.1; p < 0.0005); again no other main effect or interaction reached significance (all F-values < 1.6; p-values > 0.20). For the final time period (21:00 – 24:00 h) habitual breakfast eaters consumed fewer calories compared to breakfast omitters (186 ± 116 vs. 325 ± 227 kcal; $F_{1,33}$=5.14; p = 0.03). No other main effects or interactions were significant (all F-values < 1.0; p-values > 0.35). To summarise the above findings, during the afternoon (12:00 – 18:00 hrs.) more calories were consumed in the no breakfast condition compared to the breakfast condition. After 18:00 h the overweight and obese individuals consumed more irrespective of experimental manipulation and breakfast habit, and after 21:00 h breakfast habit influenced energy intake with breakfast omitters consuming more than breakfast eaters.

3.2 Macronutrient Intakes

More carbohydrate was consumed per day (breakfast: 239.2 ± 74.9 g; no breakfast 202.7 ± 76.1 g) during the breakfast condition by all groups ($F_{1,33}$ = 16.38, p < 0.001); There was also a significant interaction between breakfast condition and BMI for total sugar intake ($F_{1,33}$ = 9.01, p = 0.005). Normal weight and overweight participants had similar total sugar intakes during the breakfast condition (normal weight: 104.9 ± 43.4 g; overweight: 100.1 ± 64.5 g). However, during the no breakfast condition overweight participants consumed more sugar (112.6 ± 62.2 g) while normal weight participants consumed less sugar (75.3 ± 37.5 g). Full results arranged by breakfast condition, BMI and breakfast habit are shown in Table 2.

Table 2.

Energy and macronutrient intakes

About here

There was a significant three-way interaction between breakfast condition and BMI and breakfast habit on alcohol intake ($F_{1,33} = 4.87$, $p = 0.03$). Analysis of the interaction plots indicated that during the no breakfast condition, normal weight breakfast eaters and overweight breakfast omitters had similar alcohol intakes which were both higher than the intakes of both groups of breakfast eaters. Normal weight breakfast eaters had the lowest mean alcohol intake in the no breakfast condition. The highest alcohol intake was observed for overweight breakfast omitters during the breakfast condition, while regular breakfast eaters who were overweight consumed least alcohol. Normal weight breakfast eaters and omitters had similar intakes (see Table 2).

3.3 Micronutrients

The micronutrient intakes for each group are reported in Table 3. Folate (breakfast: 268.1 ± 102.4 μg; no breakfast 197.5 ± 94.0 μg), iron (breakfast: 12.2 ± 4.0 mg; no breakfast 9.6 ± 3.1 mg) and fibre intake (breakfast: 16.5 ± 5.9 g; no breakfast 14.5 ± 6.6 g) were significantly greater in the breakfast condition ($F_{1,33} = 16.70$, $p < 0.001$, $F_{1,33} = 22.79$, $p < 0.001$ and $F_{1,33} = 11.14$, $p = 0.002$ respectively).

There was a significant main effect of breakfast habit. Regular breakfast eaters had higher calcium (eaters: 738.3 ± 307.8 mg; omitters: 581.7 ± 203.0 mg), vitamin E (eaters: 8.3 ± 3.39 mg; omitters: 6.4 ± 2.7 mg) and fibre intakes (eaters: 17.8 ± 6.8 g; omitters: 12.9 ± 4.5 g) than breakfast omitters ($F_{1,33} = 4.16$, $p = 0.05$, $F_{1,33} = 4.57$, p =

0.04 and $F_{1,33}$ = 7.454, p = 0.01, respectively). There was no significant difference between mean daily intake of calcium and the reference nutrient intake for the UK (RNI) of 700mg/d, for any group in the breakfast (694.86 ± 294.16 mg/d; $t_{(36)}$ = -0.11; p = 0.92) and no breakfast conditions (629.32 ± 247.51 mg/d; $t_{(36)}$ = -1.74; p = 0.09). Mean daily intakes of folate were significantly greater than the RNI of 200 µg/d, in the breakfast condition (268.08 ± 102.43 µg/d; $t_{(36)}$ = 4.04; p < 0.001). Folate intake during the no breakfast condition was similar to the RNI (197.5 ± 94.03 µg/d; $t_{(36)}$ = -0.16; p = 0.87).

Table 3.
Micro-nutrient intakes
About here

4. Discussion

The present study demonstrated significant interactions of timing, BMI and habitual breakfast habit on energy intake. Overweight participants consumed greater amounts of energy than normal weight participants during the early evening, whereas breakfast omitters consumed more energy later in the evening when compared to habitual breakfast eaters.

In a US study investigating sleep timing and macronutrient intake in 52 participants of a similar age and gender distribution to this study, it was found that eating in the evening or before sleep resulted in higher daily energy intakes which was associated with greater body weight [3]. Although the overweight and obese participants in this study did not appear to be consuming greater total amounts of energy, they were consuming more in the evening; however, under-reporting in the obese participants needs to be considered [34]. It has been suggested that eating in the evening causes circadian disruption which may affect dietary patterns and body weight regulation long term [22] since eating has been described as a very potent synchronizer (*Zeitgeber*) for peripheral body clocks [20]. Similarly to food intakes, sleep influences circadian rhythms and late sleepers tend to consume more calories in the evening [3]; furthermore, late sleepers in some age groups are reported as being more likely to be breakfast omitters [7]. In a previous study it was shown that degree of 'morningness' (a validated measure of circadian rhythm and diurnal preference that can be assessed using the Composite Morningness Questionnaire) [4] is positively correlated with frequency of breakfast consumption [26]. People classified as having ‘evening type’ behaviour being less likely to consume breakfast; however, sleep habits were not recorded as part of this study.

Perhaps not surprisingly, and similarly to the work of Astbury et al. [2] and Hubert, King & Blundell [27] it was found that energy compensation occurred at lunchtime and later in the afternoon when breakfast was omitted. Although greater amounts were consumed later in the day following breakfast omission, in terms of total intakes over the whole day, greater amounts of energy and carbohydrate were eaten by all participant groups in the breakfast condition. It has been reported previously that people compensate less for an energy surplus than for an energy deficit [30,31], but studies comparing daily energy intakes when breakfast is eaten and when it is omitted have presented conflicting results. Some suggest that consuming breakfast is associated with the ingestion of more energy per day than when it is omitted [33,43] and that reducing the amount of energy consumed at breakfast can lower total daily energy intakes [40]. However, these studies contradict the findings of Ruxton & Kirk [37] and Song et al. [41] who found no difference in daily energy intake regardless of whether breakfast was eaten or not. Taking this into consideration, our study adds to the existing evidence that omitting breakfast per se does not necessarily result in increased daily energy intakes, and may actually be associated with lower overall daily energy intakes as in this study. However, timing of food intake may be an important consideration since overweight and obese individuals tended to consume more calories in the evening com- pared to normal weight individuals. However, energy intake later in the evening (21:00 h to midnight) is more dependent on habitual breakfast eating or omission rather than BMI. Other than some immediate partial compensation following the omission of breakfast, neither of the effects of BMI nor breakfast habit was modified by the experimental conditions; BMI and breakfast habits having independent effects on early and late evening energy consumption respectively.

Interestingly, protein and fat intakes did not change across breakfast conditions in the present study nor differ between groups; seemingly these macronutrients are more easily compensated for as they are per- haps less offset by a carbohydrate-based breakfast. However, whilst sugar intakes were similar between groups during the breakfast condition there were differences during the no breakfast condition where the overweight participants consumed more sugar and normal weight participants consumed less sugar than during the breakfast condition. Sugar intakes have previously been reported to be higher in people who omit breakfast [16] and may reflect differences in food selection between the normal weight and overweight participants when compensating for an energy deficit.

Differences were reported in alcohol intakes, with overweight habitual breakfast eaters consuming less than normal and overweight breakfast omitters. This finding has been reported previously [25,38] and perhaps adds weight to the theory that breakfast eating is a marker of a healthy lifestyle [2,37]. However, these findings should be interpreted with caution as the behaviour of the normal weight eaters in the current study was more variable. Although they had the lowest alcohol consumption of all groups in the no breakfast week they consumed similar amounts to normal weight omitters during the breakfast week. Further studies on the links between healthy behaviours, such as breakfast consumption, and alcohol intake are required.

Similarly to the findings of Halsey et al. [26] there is evidence that omitting breakfast results in lower daily intakes of folate and calcium. The present study also found evidence of reduced intakes of fibre (see also Barton et al. [5]), and iron when breakfast was not eaten. Breakfast cereals are commonly high in fibre and are fortified with folic acid and iron and consumed with milk and therefore make important contributions to the intakes of these micronutrients [45]. Given that under-reporting of food intake is common and is often reported as being more prevalent in overweight participants [32,34], studies further investigating the minutiae of energy intakes and food composition eaten by groups with different BMIs during the evening and nocturnally and with a greater number of participants are perhaps warranted. Other limitations of the study are that one week may simply not be a long enough time frame to see changes in eating habits; eating habits that affect energy intakes may take longer to establish and are dependent on levels of motivation [29]. This study is also reliant on self-reported data that may not always be accurate; however, there are studies that suggest that food diaries are reasonably robust [42,13].

This study has shown that overweight participants consumed greater amounts of energy than normal weight participants in the early evening, and breakfast omitters consumed more late at night compared to breakfast eaters, independent of experimental condition. Removing breakfast also affected the timing of subsequent energy intakes with more energy being consumed during the afternoon. Regardless of BMI and usual breakfast habit, significantly less energy, carbohydrate and fibre were consumed in no breakfast conditions. However, supplementary work including physiological and psychological studies that incorporate measures of circadian rhythm, are clearly required to further elucidate links between breakfast consumption, the timing of food in- take and BMI. As such habitual food behaviours and the timing of food intake are important considerations when investigating why breakfast consumption may be associated with BMI.

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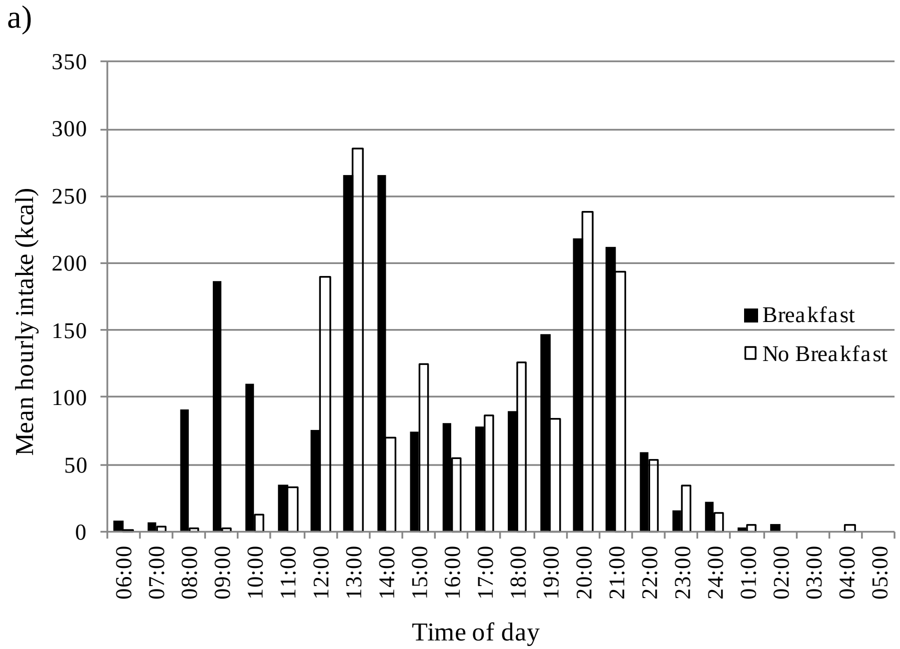
Table 1: Descriptions (mean ± SD) of participants according to breakfast habit and body mass index (BMI).

Weight	Normal weight			Overweight		
Breakfast Habit	Combined (n = 18)	breakfast eaters (n= 9)	breakfast omitters (n= 9)	Combined (n = 19)	breakfast eaters (n= 10)	breakfast omitters (n= 9)
BMI (kg/m^2)	21.31 ± 1.79	21.55 ± 1.32	21.08 ± 2.22	29.63 ± 5.32	30.49 ± 6.72	28.68 ± 3.33
Weight (kg)	63.67 ± 7.69	66.66 ± 5.88	60.68 ± 8.43	86.76 ± 19.73	91.15 ± 25.12	81.89 ± 10.73
Height (m)	1.73 ± 0.10	1.76 ± 0.09	1.70 ± 0.09	1.71 ± 0.09	1.72 ± 0.11	1.69 ± 0.06
Waist circumference (m)	0.77 ± 0.062	0.79 ± 0.056	0.75 ± 0.06	0.94 ± 0.16	0.98 ± 0.18	0.89 ± 0.12
Age (years)	29.5 ± 7.9	30.0 ± 7.9	29.0 ± 8.4	36.2 ± 16.3	36.2 ± 15.6	36.1 ± 18.0
Frequency of usual breakfast consumption (days/week)	N/A	6.8 ± 0.7	0.4 ± 0.7	N/A	5.9 ± 1.4	0 ± 0



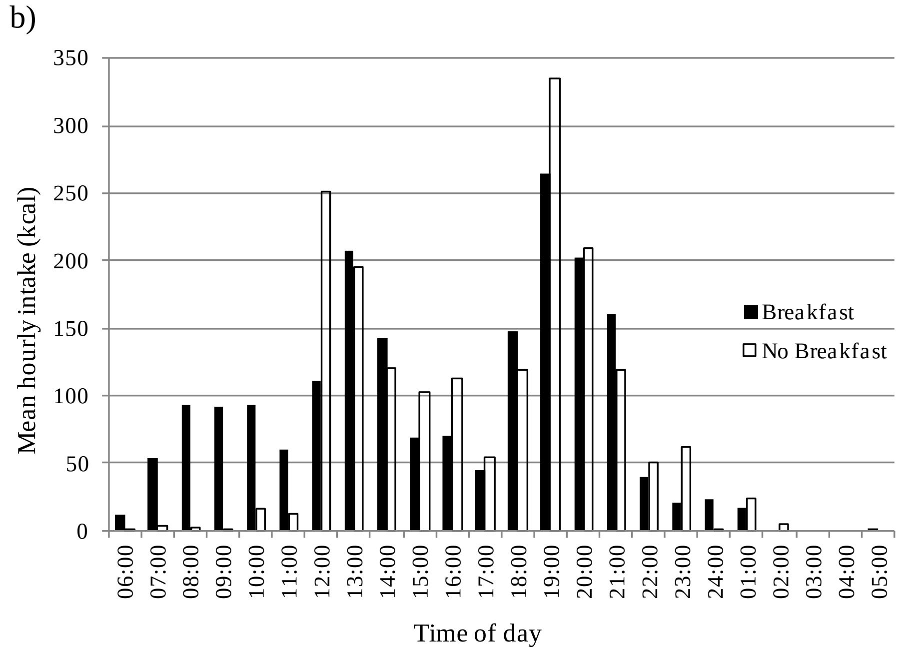


Figure 1: Mean hourly energy intake over 24-hour period during breakfast and no breakfast conditions for (a) normal weight individuals, and (b) overweight individuals.

Table 2: Mean (± SD) energy and macronutrient intakes per day in breakfast and no breakfast conditions

Condition	Breakfast Condition					No Breakfast Condition				
Group	Normal weight breakfast eaters	Normal weight breakfast omitters	Overweight breakfast eaters	Overweight breakfast omitters	Total mean ± SD	Normal weight breakfast eaters	Normal weight breakfast omitters	Overweight breakfast eaters	Overweight breakfast omitters	Total mean ± SD
Energy (Kcal)	2031 ± 499	1900 ± 555	1965 ± 445	1894 ± 528	1948 ± 488*	1714 ± 569	1683 ± 623	1859 ± 402	1887 ± 519	1787 ± 516
Carbohydrate (g)	252 ± 66	233 ± 74	239 ± 73	234 ± 96	239 ± 75**	192 ± 47	187 ± 77	225 ± 70	205 ± 106	202 ± 76
Protein (g)	80 ± 31	69 ± 29	77 ± 17	69 ± 23	74 ± 25	71 ± 20	67 ± 22	72 ± 16	72 ± 24	70 ± 20
Fat (g)	77 ± 28	64 ± 32	79 ± 17	70 ± 22	73 ± 25	77 ± 40	70 ± 29	74 ± 17	72 ± 25	73 ± 28
Alcohol (g) $^{\delta}$	74 ± 84	70 ± 84	49 ± 80	104 ± 96	74 ± 85	14 ± 25	82 ± 92	60 ± 69	90 ± 92	61 ± 77

* Significantly greater energy intake in the breakfast condition compared to no breakfast condition (p=0.03)
** Significantly greater carbohydrate intake in the breakfast condition compared to no breakfast condition (p=0.001)
$^{\delta}$ There was a significant three-way interaction between breakfast condition and BMI and breakfast habit on alcohol intake (p = 0.03)

Table 3: Mean (±SD) Sugar and micronutrient intakes in breakfast and no-breakfast conditions

Condition	**Breakfast Condition**					**No Breakfast Condition**				
Group	**Normal weight breakfast eaters**	**Normal weight breakfast omitters**	**Overweight breakfast eaters**	**Overweight breakfast omitters**	**Total mean ± SD**	**Normal weight breakfast eaters**	**Normal weight breakfast omitters**	**Overweight breakfast eaters**	**Overweight breakfast omitters**	**Total mean ± SD**
Total sugar (g) *	119 ± 43	91 ± 41	97 ± 51	104 ± 80	102 ± 55	82 ± 35	69 ± 41	106 ± 50	119 ± 76	94 ± 54
Fibre (g) **, δ	19.6 ± 4.8	13.5 ± 4.4	17.9 ± 8.0	14.6 ± 3.8	16.5 ± 5.9	19.0 ± 6.2	10.3 ± 4.3	15.0 ± 7.7	13.4 ± 5.1	14.4 ± 6.6
Calcium (mg) **	762 ± 339	580 ± 216	845 ± 343	576 ± 179	695 ± 294	664 ± 314	593 ± 262	678 ± 244	577 ± 181	629 ±248
Zinc (mg)	9.0 ± 2.9	7.1 ± 3.2	8.6 ± 2.1	7.7 ± 3.5	8.1 ± 2.9	7.3 ± 2.9	7.6 ± 2.9	7.9 ± 3.1	7.6 ± 2.1	7.6 ± 2.7
Iron (mg) δ	14.3 ± 3.9	11.0 ± 3.3	12.8 ± 4.4	10.8 ± 3.9	12.2 ± 4.0	10.7 ± 3.7	8.7 ± 3.3	9.3 ± 2.6	9.8 ± 3.0	9.6 ± 3.1
Folate (µg) δ	295 ± 82	255 ± 112	271 ± 140	251 ± 68	268 ± 102	258 ± 140	160 ± 70	188 ±79	185 ± 50	198 ± 94
Vitamin C (mg) *	167 ± 130	204 ± 188	67 ± 41	143 ± 174	143 ± 146	99 ± 45	83 ± 79	126 ±120	107 ± 100	104 ± 89
Vitamin B12 (µg)	3.6 ± 3.4	3.0 ± 1.1	4.1 ± 1.9	3.2 ± 1.9	3.5 ± 2.2	4.2 ± 2.5	3.0 ± 1.7	3.7 ± 1.8	4.2 ± 2.5	3.8 ± 2.1
Vitamin D (µg)	1.5 ± 1.6	1.8 ± 1.2	2.7 ± 2.2	2.1 ± 1.3	2.0 ± 1.6	2.3 ± 2.0	1.6 ± 1.3	3.2 ± 2.7	1.5 ± 0.8	2.2 ± 1.9
Vitamin E (mg) **	8.1 ± 4.0	6.4 ± 3.0	8.8 ± 3.5	7.0 ± 2.8	7.6 ± 3.4	8.7 ± 3.8	5.9 ± 2.7	7.7 ± 2.7	6.1 ± 2.6	7.1 ± 3.1

* Significant interaction of breakfast condition x BMI for total sugar ($p = 0.005$) and vitamin C ($p = 0.01$) intakes.
** Breakfast habit is significantly associated with fibre ($p = 0.01$), calcium ($p = 0.050$) and vitamin E ($p = 0.04$) intakes.
δ Breakfast condition had significant effects on fibre ($p = 0.002$), iron ($p < 0.001$), folate ($p < 0.001$) and vitamin C ($p = 0.04$) intakes.