



SAHLGRENSKA AKADEMIN

DOES EATING FREQUENCY CORRELATE WITH OVERWEIGHT AND OBESITY AMONG SWEDISH MEN AND WOMEN?

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Abstract

Title: Does eating frequency correlate with overweight and obesity among Swedish men and women?

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Background: Obesity is an increasing problem worldwide and it increases the risk for many diseases such as diabetes, cardiovascular disease and cancer. An increased total energy intake due to an increased eating frequency has been noted by several studies, and this is one factor discussed as contributing to the obesity epidemic. The existing evidence about eating frequency and BMI is however conflicting.

Aim: The aim of this study is to investigate if eating frequency among Swedish men and women from a national dietary survey is associated with overweight or obesity, reported energy and macronutrient intake.

Method: Data for this secondary analysis was collected from the Riksmaten 2010-11 survey, a cross-sectional/observational survey. The Riksmaten method is a web based four-day food record. A total of 1797 participants completed the food record and a background questionnaire including height, weight and physical activity. Statistical tests were independent t-test, chi-square and spearman correlations.

Result: Mean eating frequency was 4.5 for men and 4.7 for women ($p < 0.001$). Eating frequency was not significantly correlated with BMI, but with energy intake for both men ($r_s = 0.45$) and women ($r_s = 0.45$). Energy intake was not significantly correlated with BMI. Eating frequency was correlated with a higher percent energy from carbohydrates and fiber, and a lower percent energy from protein and fats.

Conclusion: The results of this study showed that eating frequency was not correlated with BMI, however it was correlated with a higher energy intake and macronutrient composition. The different definitions of an eating occasion make it difficult to compare the results to other studies. Future studies should agree on using one set definition for an eating occasion and also evaluate the type of foods eaten. Longitudinal and interventional studies should be made to find if eating frequency does affect BMI.

Sammanfattning

Titel:	Finns det ett samband mellan ätfrekvens och övervikt och fetma bland svenska män och kvinnor?
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Bakgrund:	Övervikt är ett växande problem i hela världen, och ökar risken för ett flertal sjukdomar som diabetes, kardiovaskulära sjukdomar och cancer. Ett ökat energiintag på grund av en ökad ätfrekvens har observerats av flera studier, och är en av de diskuterade bidragande faktorerna till fetma epidemin. Den existerande evidensen angående ätfrekvens och BMI är motstridig.
Syfte:	Syftet med studien är att undersöka om ätfrekvens bland svenska män och kvinnor utifrån en nationell kostundersökning är associerat med övervikt och fetma, rapporterat energiintag och makronutrientintag.
Metod:	Data i den här sekundära analysen har samlats in i matvaneundersökningen Riksmaten 2010-11, som är en tvärsnitts-/observationsundersökning. Riksmaten metoden är en web-baserad fyra dagars kostregistrering. Totalt 1797 deltagare slutförde registreringen och svarade på ett frågeformulär med bakgrundsfrågor, längd, vikt och fysisk aktivitet. Independent t-test, chi-square och spearman korrelation användes för de statistiska analyserna.
Resultat:	Medel ätfrekvens var 4,5 för män och 4,7 för kvinnor ($p < 0,001$). Ätfrekvens var inte signifikant korrelerat med BMI, men med energiintag för både män ($r_s = 0,45$) och kvinnor ($r_s = 0,44$). Energiintaget var inte signifikant korrelerat med BMI. Ätfrekvens var korrelerat med en högre procent energi från kolhydrater, och en lägre procent energi från protein och fett.
Konklusion:	Resultatet av studien visar att ätfrekvens inte var korrelerat med BMI, men med ett högre energiintag och med andelen energi från makronutrientier. De olika definitionerna för ett ättillfälle gör det svårt att jämföra resultaten med andra studier. Framtida studier bör använda en bestämd definition för ett ättillfälle och också utvärdera livsmedelsval. Longitudinella studier och interventionsstudier bör göras för att ta reda på om ätfrekvens påverkar BMI.

Abbreviations

BMI	Body Mass Index
BMR	Basal Metabolic Rate
CNS	Central Nervous System
EE	Energy Expenditure
E%	Energy percent
GLP-1	Glucagon-like peptide 1
Kcal	Kilocalorie
LDL-cholesterol	Low-density lipoprotein cholesterol
NNR	Nordic Nutrition Recommendations
PAL	Physical Activity Level
WHO	World Health Organization

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Background

Obesity is an increasing problem worldwide (1), and it increases the risk for many diseases such as diabetes, cardiovascular disease and cancer (2). Sweden is no exception with a prevalence of overweight of 49% and of obesity of 13% in the population over 16-years (3). The etiology for the growing epidemic of overweight and obesity is very complex, but there are many suggested contributors, such as poor diet and consumption of fast food, increased portion sizes, and a decrease in physical activity. All these factors together contribute to a positive energy balance. An increased total energy intake due to an increased eating frequency has been noted by several studies (4-6), and this is one factor discussed as contributing to the obesity epidemic (7).

Energy balance and weight

Energy balance is required for weight maintenance, and it is well known that a positive energy balance leads to weight gain, and a negative energy balance leads to weight loss. Energy balance, as in kcal consumed equals kcal utilized, is different for each individual and depends on weight, gender, activity level, amount of lean body mass and genetics (8). Individuals who are more physically active burn more kcal and can therefore eat more food and still maintain their weight. Basal Metabolic Rate (BMR) indicates the amount of kcal used in rest for the body to function. Total Energy Expenditure (EE) includes the BMR and all physical activity performed during a day (8).

The regulation of energy balance in an individual is very complex, but shortly, energy balance is regulated by responses from the Central Nervous System (CNS) to hormones like insulin, leptin and GLP-1. These hormones reflect body fuel status. Likewise the CNS responds to ingested nutrients, which inform about the energy status of the body (9). In obesity, it is likely that these signals are impaired, which leads to energy imbalance and obesity (9, 10).

Classifications for overweight and obesity

The World Health Organization (WHO) classifies overweight and obesity according to Body Mass Index (BMI), where a BMI over 25 kg/m² is the cut-off point for being overweight, and a BMI over 30 kg/m² is the cut-off point for obesity. A high BMI is associated with increased risk of co morbidities, and the higher the BMI, the higher the risk becomes (11). However BMI is a crude measurement that does not distinguish between fat mass and muscle mass, nor does it tell anything about where in the body the fat is stored. Abdominal fat accumulation is known to increase the risk of metabolic complications, waist circumference provides more information on this. A waist circumference over 80 cm and 94 cm for Caucasian women and men respectively indicates an increased risk for metabolic complications (11).

Eating frequency

Eating frequency can be defined as how often a person eats, or how many eating occasions a person has in one day. Physiological, psychological and sociological factors all together control the feeding behavior of humans. What determines eating frequency could be the amount eaten at one occasion, how much food is left in the stomach as well as social and environmental factors (12).

Studies done on eating frequency have used different definitions to describe an eating occasion. Some studies require a minimum intake of 50 kcal to count for an eating occasion, while other studies have no minimal energy requirement but any solid food eaten. The minimum time required to elapse between two eating occasions could also vary from 15 minutes to one hour (13-16). Even the inclusion of drinks in an eating occasion varies, while some chose to not include drinks at all in the definition of an eating occasion, others included even energy free drinks (17). This makes it hard to draw any conclusions from the existing research.

It has been suggested that eating frequency is positively associated with health. Several studies have found an inverse relationship between eating frequency and BMI (13, 14, 16, 18), and some studies have found that a higher eating frequency was associated with lower total cholesterol and LDL-cholesterol (19-21), and an improved glucose homeostasis (22-24).

Eating frequency and weight

The habitual eating frequency and body weight has been studied by several researchers, where many noted that a more frequent eating pattern was often associated with a lower weight or decreased risk for obesity (13, 14, 16, 18). However other studies have observed that a higher eating frequency was associated with a higher BMI (15).

Zizza et al. (2001) observed from the USDA's nationally representative surveys, that over the years there has been an increase in the frequency of snacking as well as the energy density of foods consumed in young US adults. The authors conclude that the increase in the total energy intake followed by the more frequent snacking of energy dense foods, could be one of the causes to the growing obesity epidemic (7).

As for studies that observed a more frequent eating pattern related to a lower BMI, Bellsile et al. (1997) suggested one explanatory reason being greater under-reporting from overweight and obese participants.(25) One way to measure accuracy of self reported intake is to compare it with actual energy expenditure by using double labeled water. Studies using double labeled water have frequently found, that self-reported dietary intake is often an underestimation. Just like Bellsile et al. (26) suggested that obese participants more often tend to under-report, Livingstone et al. states in their article; "The probability of underreporting increases as BMI increases" (26)

Eating frequency and appetite

Appetite can be described as the desire to eat, or perceived hunger. A higher eating frequency has been believed to support weight loss by for example supporting appetite control (27-29). Several studies have looked into the subject, but common problems with these studies are a small sample size and the lack of standardized measure of hunger an appetite. Also the definition of a meal or eating occasion can vary among studies.

A study performed by Speechly et al. (1999) investigated how eating frequency affected perceived hunger and food intake at a later meal. Seven obese men participated in the study and were given equal amounts of energy in either one single meal or five small meals with one hour between the meals. Five and a half hours from the first meal participants received a test meal, that they could consume ad libitum. The group that had only eaten one big meal earlier consumed significantly more food than the more frequent meal group. There were no significant differences in perceived hunger (27).

The same researcher used the same protocol on eight lean men, and the same results were obtained. The frequent meal group ate significantly less food at the test meal, and their hunger ratings and urge to eat right before the test meals were lower. The authors conclude that since there were no differences in the participant blood glucose concentrations between the two groups prior to the test meal, the difference in the consumption of the test meal could not be explained with glucose homeostasis. On the other hand they observed differences in insulin levels between the groups, where the more frequent meal group had a more steady insulin concentrations throughout the day, and the concentrations did not peak after the test meal (28).

The idea of having a snack or a smaller meal between two main meals, even when not feeling hungry, is usually to prolong the feeling of satiety and to reduce the feeling of hunger before the next meal. As demonstrated in the earlier mentioned studies, this would decrease the amount of food eaten at the upcoming meal (27, 28). However, this might not always be the case. A snack provided in between two meals doesn't necessary prolong the satiety of the previous meal, decrease the hunger before the next meal, or decrease the amount eaten at the upcoming meal and thus only add more calories to the day (30).

Also in contrast to the previous studies that compared one single big meal to five smaller meals, one research group compared perceived hunger and desire to eat in groups consuming either three meals or six meals a day. This study found that six meals a day seemed to increase desire to eat (31). Another study also concludes that a higher eating frequency does not necessarily decrease appetite, and that the role of macronutrients consumed may be of greater importance than frequency of meals (32).

What about macronutrients?

Humans get energy from four different macronutrients; carbohydrate, fat, protein and alcohol. Several studies suggest that protein is the most satiating of the macronutrients, and leads to a lower energy intake (33, 34).

If a higher meal frequency would support appetite control, it could be assumed that combined with a higher protein intake this method would be more effective. Leidy et al. (2010) tested this hypothesis in their study, where participants received four treatments, three and six meals with both low and high protein intakes. However in this study, independent of protein intake the higher frequency meal resulted in a lower daily feeling of fullness, and independent of meal frequency the higher protein intake resulted in greater daily fullness (35).

Meals or snacks consumed in the form of pastries and sweets, with high carbohydrate and fat content but low protein content provide high amounts of energy but are not as satiating as protein rich meals. A study done by Bertéus Forslund et al. observed an association with a higher frequency of snacks and a lower protein intake and a higher fat intake among obese men and women. Interestingly the same associations were not found in the reference group (36).

Other studies have found that a higher eating frequency was associated with a higher intake of carbohydrates and a lower intake of fat and protein (37, 38), and in one of the studies a higher eating frequency was associated with a healthier lifestyle, but not with a higher BMI (37).

It seems like the type of foods associated with an increased eating frequency would affect body weight more than eating frequency by itself. Obese individuals seem to have a higher fat intake with an increased eating frequency, while normal weight individuals have a higher carbohydrate and lower fat intake.

Earlier studies on eating frequency in Swedish populations

Bertéus Forslund et al. has earlier demonstrated that obese women report a higher eating frequency than reference women (39). The same researchers also found a higher frequency of snacks in obese men and women compared with reference men and women. The obese women were the most frequent snackers (36). The difference in reported intake occasions between the obese and the reference participants was only one occasion.

A study by Holmbäck et al. (2010) found that a lower eating frequency was associated with an increased likelihood of obesity and central obesity, and a higher eating frequency was associated with an overall healthier lifestyle (37).

Another study found no association between eating frequency and obesity, but found that obese subjects more often omitted breakfast and lunch and thus ate more later in the day. They also observed that obese subjects reported significantly larger portion sizes than the non-obese subjects (40).

The Nordic Nutrition recommendations (NNR) 2004 gave an example of how the daily food intake could be distributed. It included three main meals and one to three intermediate meals. Even though they mentioned the lack of data for any universal and optimal eating patterns, a regular eating pattern was still recommended (41). In the latest NNR 2012 recommendations about eating patterns are not mentioned at all (42).

Why is it important to study eating frequency?

Obesity is a growing problem, and costs millions to the government (43). In today's society where food is available everywhere and around the clock, especially in the bigger cities, eating more frequently is easily achieved. It is known that a positive energy balance lead to weight gain, and most studies seem to associate a higher eating frequency with and increased total energy intake (4-6). The existing evidence about eating frequency and BMI is however conflicting.

No study has so far investigated eating frequency in a national dietary survey in Sweden. The aim of this study is therefore to increase the knowledge of eating frequency in relation to obesity.

Aim

The aim of this study is to investigate if eating frequency among Swedish men and women from a national dietary survey is associated with overweight or obesity, reported energy and macronutrient intake.

Research question

1. How many eating occasions do Swedish men and women report, and does the number of eating occasions differ between men and women?
2. Is the number of eating occasions related to BMI
3. A) Is the number of eating occasions related to energy intake?
B) Is energy intake related to BMI?
4. Is there any association between the number of eating occasions and macronutrients?

Material and Methods

Subjects and recruitment

“Riksmaten 2010-11” is a cross-sectional/observational survey performed by the Swedish National Food Agency. The participants, aged 18-80 years, were randomly selected from the Swedish Population Registry by Statistics Sweden. The selection was stratified by gender and age group (18-30;31-44;45-64;65-80 years) and region. In total 5000 men and women were invited to participate and 1797 men and women recorded their daily food intake during four days and are included in this study. The overall participation rate was 36% and the participants had somewhat higher education compared to those who declined the invitation. The youngest men were less likely to take part in the survey than women and older men (44).

The Riksmaten survey

The recruitment was planned so the starting dates for the participant’s food registration were evenly distributed over gender and age. Starting days were Tuesday, Wednesday, Saturday and Sunday.

The information was collected between May 2010 and July 2011. An invitation was sent to the selected population by mail. The ones who responded yes to the invitation received further material and information about the survey. They got called up by trained interviewers at Statistics Sweden who further described the study and materials, and answered questions the participants had in mind.

Every participant was asked to complete a questionnaire of 53 questions. The questions covered the participants’ background, reproduction, work and leisure time physical activity, frequencies of foods not consumed every day, supplements, living situation etc. The participants were also asked to report their weight, height, waist- and hip circumference.

During the study every participant was contacted by phone and was offered help with the registration of food if needed. They were also offered a new starting date if the participant had not been able to start on the given date. Participants who did not own a computer or for other reasons could not register their food intake online, had the possibility to report everything they ate and drank over the phone to one of the interviewers who registered the food for them. This was done twice, in the middle of the recording period and the end of the period. Participants who completed the food record and the questionnaire received a gift card worth 100 SEK. Participants also received feedback regarding their diet afterwards.

The “Riksmaten method”

The Riksmaten method is a web based four-day food record. The most important aspect of the Riksmaten survey is that it is possible to measure the consumption of food as detailed as possible, as in what, when and how much. The Swedish National Food Agency worked together with IT-consultants to build up the internet based webpage where the participant would be able to register their daily food intake from a food list specifically developed for the survey. The database for the foods contained nutritional information for 1900 different foods, dishes and processed products. The number of choices had to be limited to a manageable amount, and this was done by for example combining different types of red meat to either boiled meat or fried meat. Stews are divided in groups depending on which base was used, for example coconut milk, cream or water. Energy and nutrient intake was calculated in the computer system administering the Riksmaten method and the food composition database described above. (Livsmedelsdatabasen version Riksmaten 2010). It was also possible to calculate number of eating occasions in the system (45, 46).

To facilitate the searching, foods were divided based on food category, cooking method and main ingredient. Even dish type and popular names could be used to search for different foods. Amounts of food eaten could be recoded as piece, deciliter, gram, slice, pieces or portion. Every portion size had the amount in grams, and the participants got a portion guide with pictures and information about different portion sizes. This portion guide was made for the study and meant to be used by the participants to facilitate estimation of portion sizes.

The participants of the study registered everything they ate and drank during four days. The time of the intake, the type of food and the place where the food was eaten was registered. Participants were able to register a new food intake every 15 minutes. If some of the consumed foods were not to be found in the database, participants were encouraged to choose the most similar option. Gluten free or lactose free options were not available in the database, and thus “normal” products of the same food had to be registered instead. Participants were encouraged to register their food intake right after a meal, but they also got a notebook where they could fill in foods they had eaten during the day for later registration. To be able to provide feedback to the participants, they also completed questions on physical activity, weight, height, gender and age. Staff could be reached with questions during the registration period either via e-mail or hotline.

Design of the secondary analysis

Background variables included in the analysis

BMI for each individual was calculated based on the participants self reported weight and height. $BMI = \text{weight in kg} / \text{height in meter}^2$. Age, sex and education level were based on the population registry from Statistics Sweden. Level of education was reported as finished studies after middle school or high school, or continued studies after high school. When the difference between men and women was compared, education was coded into either 0 or 1, 0 referring to middle school or high school and 1 to continued studies after high school.

Physical activity was self-reported in the Riksmaten method. Participants were asked to report their physical activity during both leisure time and at work. The categories for leisure time physical activity was sedentary, light, moderate or active, and for work sedentary, light, moderate or heavy. When comparing differences between men and women, both variables were coded into two levels, sedentary and light were coded as 0, while moderate and active/heavy were coded as 1.

Definition of an eating occasion

An eating occasion in this article is defined as an intake of foods and/or drink that is over 50 calories and 15 minutes apart from the last intake occasion (47, 48). Average number of eating occasions per day is used in the analyses.

Identifying low- and high-energy reporters

Riksmaten 2010-11 had already defined the exclusion criteria for low- and high-energy reporters. They used the Goldberg and Black method (49), which is based on equations to calculate lower cut-off and upper cut-off points for the study population to identify under- and over-reporters. This was done by calculating a mean physical activity level (PAL) for the entire group. Individual PAL values were estimated based on the answers in the questionnaire on physical activity during leisure time and work. Confidence intervals were calculated around the obtained mean PAL for the entire group, where individual day to day variation in the reported energy intake, variations for BMR measurements and the variation in physical activity between individuals as well as the number of registered days were taken into account. The lower cut-off point was 0.93 and the upper was 3.18 for the Riksmaten study population. This study used the same cut off points that Riksmaten 2010-11 had already calculated. To identify low and high-energy reporters, each participant's reported energy intake was divided by BMR, and individuals with values lower than 0.93 or higher than 3.18 were considered as low and high energy reporters, respectively. BMR was calculated by using equations from WHO which were based on sex, weight and age (50). The same equations were used as in Riksmaten 2010-11, and the idea behind using the same equations was so the same range for low- and high-energy reporters could be used.

Statistics

Statistics were analyzed using the program SPSS version 24. Background variables were described using means and standard deviations for men and women separately. Independent t-test was used to test for differences for number of eating occasions, BMI, energy intake, age, waist circumference and macronutrient intake between men and women. Chi-square was used to test for differences in proportion of high education and high physical activity level between men and women. As some of the variables were not normally distributed, Spearman correlation was used to analyze the correlation between eating frequency and energy intake, macronutrient intake and BMI. Analyses were first done on all data, without excluding low- and high energy-reporters. Afterwards, low- and high energy-reporters were excluded and analyses were made again, to see if the results differed. P-values <0.05 were considered statistically significant for all analyses.

Ethical aspects

Uppsala Regional Ethical Board has ethically approved Riksmaten 2010-2011. It was voluntary to take part in the study and participants could drop of the study if they did not want to complete the food registration. Only already existing data has been used in this secondary analysis.

Results

Population characteristics

A total of 1797 participants completed the food registration. The population characteristics are presented in table 1. Of the participants, 56 percent were females. The mean age of the participants were 50 years for men, and 47 years for women. Forty one percent of the men and 47 percent of the women had a continued education after high school. The mean BMI for the participants was 25.9kg/m² for men and 24.9 kg/m² for women. Fifty six percent of the men and 40 percent of the women were overweight or obese. After excluding low- and high-energy reporters, 325 participants were excluded. The mean BMI for men was now 25.5 kg/m² and for women 24.6 kg/m². Half of the participants reported that they were moderately active or active on their leisure time, and just over one quarter reported moderate to heavy occupational physical activity.

Table 1. Baseline characteristics of the study population

	Men (n= 792) Mean (sd)	Women (n= 1005) Mean (sd)	P-value
BMI kg/m ² (sd)	25.9 (±4)	24.9 (±4.6)	<0.001 ^a
Waist circumference cm (sd)	96 (±11.5)	87 (±12.9)	<0.001 ^a
Age years (sd)	50 (±16.3)	47 (±16.7)	0.001 ^a
Overweight ^c , %	56	40	<0.001 ^b
Moderate – active leisure time ^d , %	49	52	0.243 ^b
Moderate – heavy labor ^e , %	27	27	0.725 ^b
Higher education ^f , %	41	48	0.009 ^b

^aDifferences tested with *t*-test

^bDifferences tested with *Chi-square*

^cBMI over 25 kg/m²

^dModerate and active leisure time physical activity categories 3-4

^eModerate and heavy labor physical activity at work

^fEducation after high school

Energy intake and low energy reporting

Mean energy intake for the whole group was 1975 kcal, men reported 2236 kcal and women 1770 kcal (table 2). Energy intake for the whole group varied from 411 to 7694 kcal. After excluding low- and high-energy reporters, the lowest energy intake was 954 kcal and the highest 4897 kcal. The mean reported energy intake for men was 2428 kcal and for women 1886kcal. Of the low-energy reporters 73% were overweight (had a BMI over 25), and 67% had a lower education, meaning high school or secondary school. The mean age of the low-energy reporters was 46 years. Only three participants were excluded as high-energy reporters.

Eating frequency

Figure 1a and 1b displays the distribution of eating frequency for men and women. The mean number of reported eating occasions was significantly lower for men (4.5) than for women (4.7) (table 2). The number of eating occasions ranged from one to ten occasions. After excluding low- and high-energy reporters mean number of eating occasions was now 4.7 for men and 4.9 for women. Figure 2a and 2b displays the distribution of eating frequency for men and women after exclusion of low-and high-energy reporters. For the low-energy reporters, mean number of eating occasions was 3.6 for men and 3.9 for women.

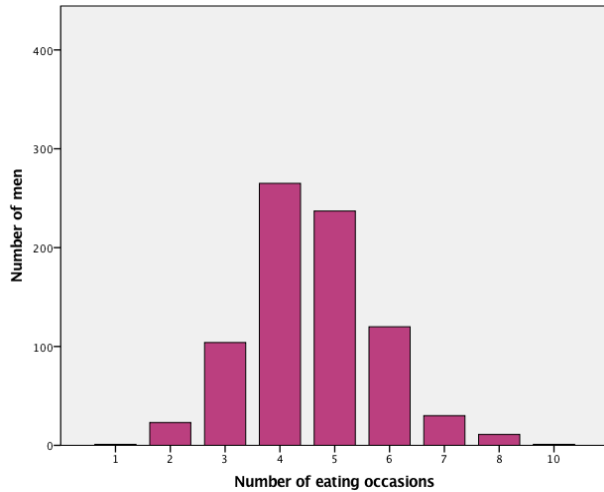


Figure 1a. Distribution of eating frequency for men

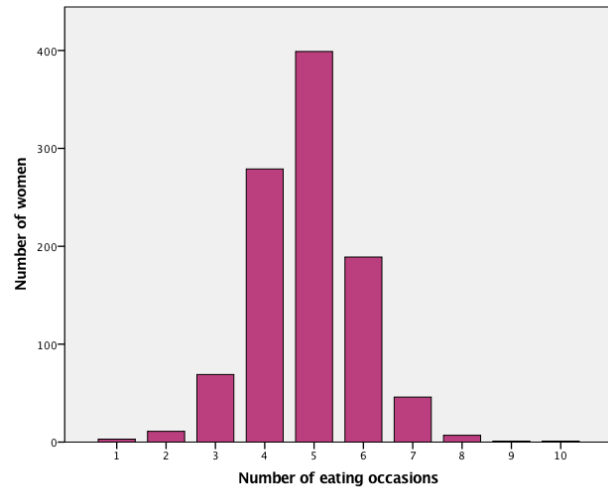


Figure 1b. Distribution of eating frequency for women

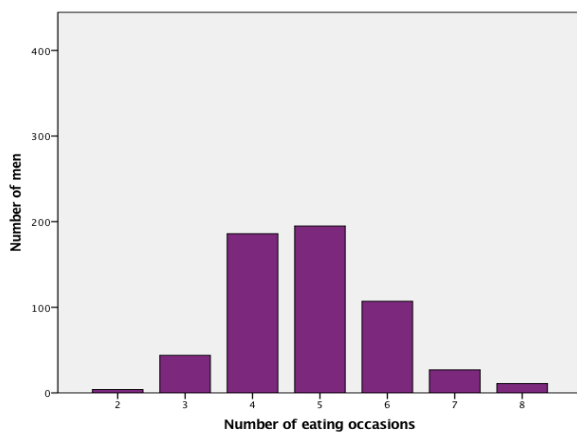


Figure 2a. Distribution over eating frequency for men after exclusion of the low- and high-energy reporters

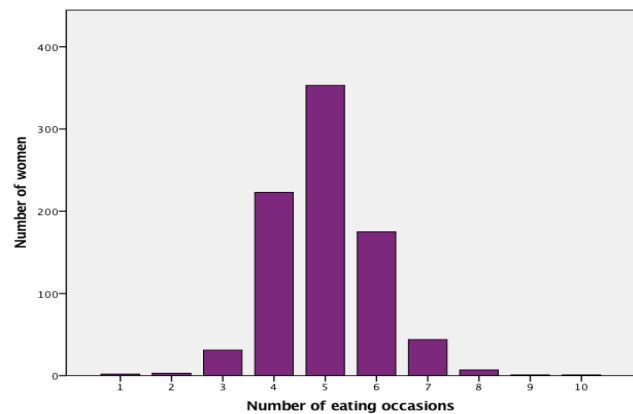


Figure 2b. Distribution over eating frequency for women after exclusion of the low- and high-energy reporters

Macronutrient intake

Mean energy intake, eating frequency and percent of energy from the four macronutrients are presented in Table 2. Energy percent carbohydrate was somewhat higher for women than for men, while energy percent alcohol was higher for men, than for women.

Table 2. Eating occasions, calorie and macronutrient intake of the study population

	Men Mean (sd)	Women Mean (sd)	P-value ^a
Energy intake kcal	2236 (\pm 661)	1770 (\pm 489)	<0.001
Eating Occasions	4.5 (\pm 1.2)	4.7 (\pm 1.03)	<0.001
E% Carbohydrates	42.6 (\pm 7.1)	43.3 (\pm 7.2)	0.047
E% Fats	34.6 (\pm 6.6)	35.0 (\pm 6.4)	0.148
E% Protein	16.8 (\pm 3.3)	16.5 (\pm 3.3)	0.113
E% Alcohol	3.9 (\pm 4.8)	2.8 (\pm 4.1)	<0.001

^aDifferences tested with t-test

E% = energy percent, the amount of energy in the food, or in the total daily energy intake, that the various macronutrients contribute with.

Correlation between eating frequency and BMI

Eating frequency and BMI was not correlated. The correlations are displayed in Figure 3a for men and Figure 3b for women. For women the r_s was -0.02 ($p= 0.611$) and for men -0.03 ($p=0.496$). After excluding low- and high-energy reporters ($n= 325$) the results only changed slightly.

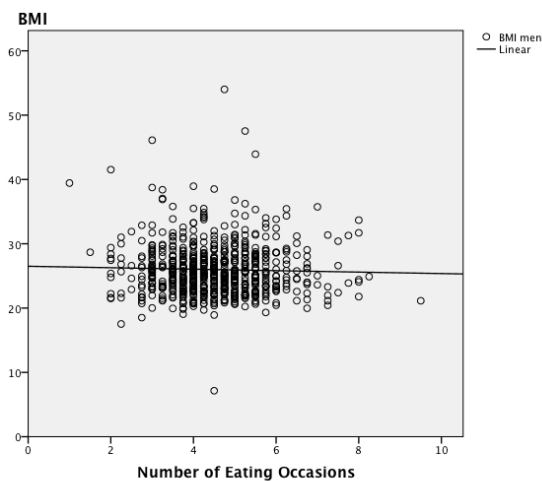


Figure 3a. Correlation between eating frequency and BMI for men

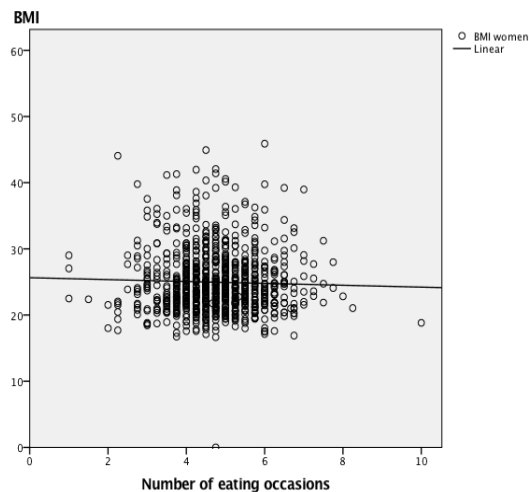


Figure 3b. Correlation between eating frequency and BMI for women

Correlation between eating frequency and energy intake

In Figure 4a and Figure 4b the correlations between eating frequency and energy intake are displayed for men and women, respectively. Eating frequency was significantly correlated with energy intake for both men ($r_s=0.45$, $p < 0.001$) and women ($r_s=0.44$, $p < 0.001$). After excluding low- and high-energy reporters, the correlations were weakened for both men ($r_s=0.27$) and women ($r_s=0.33$), but remained significant ($p < 0.001$ for both groups).

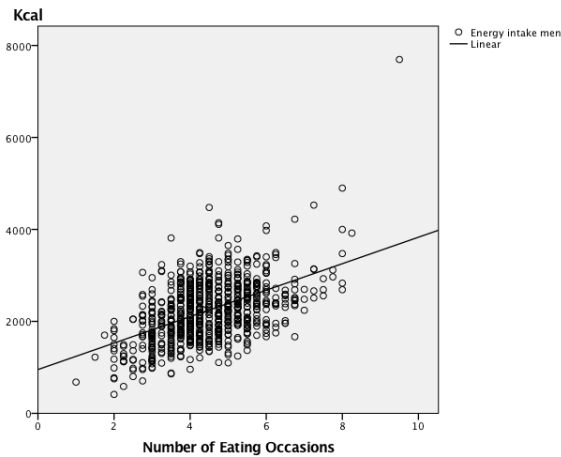


Figure 4a. Correlation between eating frequency and energy intake for men

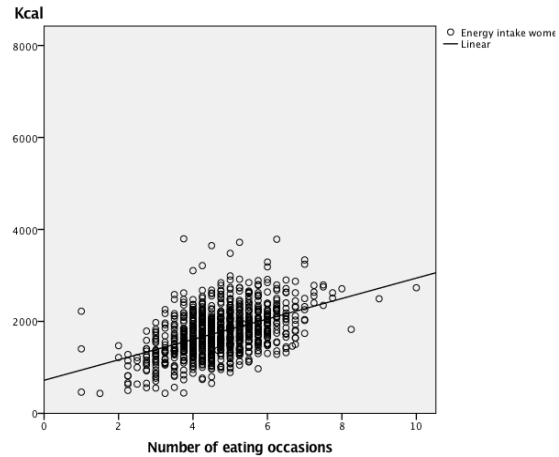


Figure 4b. Correlation between eating frequency and energy intake for women

Correlation between energy intake and BMI

In Figure 5a and Figure 5b the correlations between energy intake and BMI are displayed for men and women, respectively. BMI was significantly and negatively correlated with energy intake for both men ($r_s = -0.17$, $p < 0.001$) and women ($r_s = -0.10$, $p = 0.003$). After excluding low- and high-energy reporters, the correlations were no longer statistically significant ($r_s = -0.02$, $p = 0.663$ for men and $r_s = -0.00$, $p = 0.905$ for women).

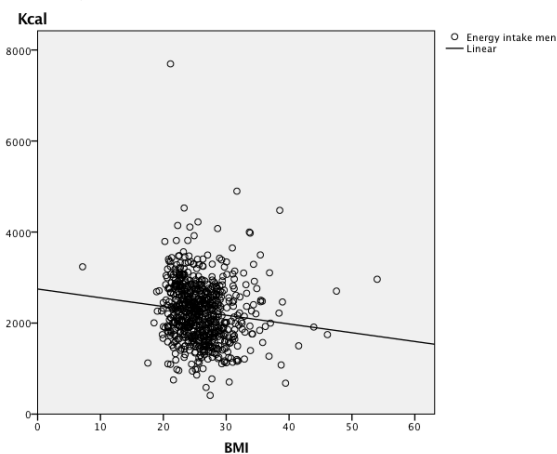


Figure 5a. Correlation between energy intake and BMI for men

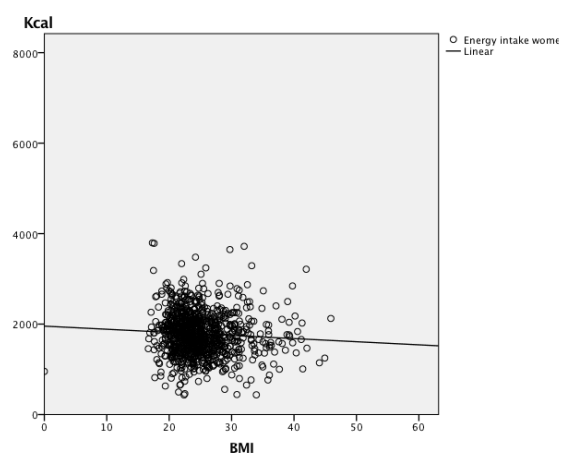


Figure 5b. Correlation between energy intake and BMI for women

Correlation between eating frequency and macronutrient intake

Table 3 presents the correlation coefficient for eating frequency and the four macronutrients.

Carbohydrates

A higher eating frequency was significantly correlated with a higher percent of energy from carbohydrates for both men and women. The correlations remained statistically significant also after excluding low- and high-energy reporters. A higher eating frequency was also significantly correlated with a higher fiber g/MJ intake ($r_s=0.17$, $p < 0.001$ for men and $r_s=0.17$, $p < 0.001$ for women), and the correlation remained significant after exclusion of low- and high-energy reporters.

Protein

Percent of energy from protein was negatively associated with a higher eating frequency in both men and women and also after excluding low- and high-energy reporters.

Fat

Eating frequency was not significantly correlated with fat intake. However after excluding low- and high-energy reporters the correlations were negative and significant in both men and women.

Alcohol

Eating frequency was weakly and positively correlated with percent energy from alcohol in men, but not in women. After excluding low- and high-energy reporters, the correlation was negative in women but no longer statistically significant in men.

Table 3. Correlations between eating frequency and macronutrient intakes before and after exclusion of low- and high-energy reporters

Before exclusion of low- and high-energy reporters		After exclusion	
		Eating frequency, r_s	Eating frequency, r_s
<i>E% Carbohydrate</i>	Men	0.16 ***	0.20 ***
	Women	0.18 ***	0.23 ***
<i>E% Protein</i>	Men	-0.33 ***	-0.23 ***
	Women	-0.20 ***	-0.14 ***
<i>E% Fat</i>	Men	-0.05	-0.15 ***
	Women	-0.04	-0.10 **
<i>E% Alcohol</i>	Men	0.08 *	0.05
	Women	-0.02	-0.11 **

* $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$

E% = energy percent, the amount of energy in the food, or in the total daily energy intake, that the various macronutrients contribute with.

Correlation between eating frequency and age, education and physical activity

Table 4 presents the correlation between eating frequency and age, education and physical activity during leisure time. A higher eating frequency was significantly correlated with a higher age. After excluding low- and high-energy reporters the correlation remained significant for men, but not for women.

A higher eating frequency was significantly but weakly correlated with a higher education for women, but not for men. However, after exclusion of low- and high-energy reporters, there was no significant correlation between education and eating frequency.

Eating frequency was not significantly correlated with physical activity.

Table 4 Correlation between eating frequency and age, education and physical activity before and after exclusion of low- and high-energy reporters

Before excluding low and high energy reporters		After excluding	
		Eating frequency, r_s	Eating frequency, r_s
Age	Men	0.24***	0.26***
	Women	0.08*	0.03
Education	Men	0.05	0.01
	Women	0.07*	0.03
Physical act	Men	0.05	-0.00
	Women	0.06	0.02

* $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$

Leisure time physical activity

A higher age was significantly correlated with a higher BMI ($r_s = 0.19$, $p < 0.001$ for men and $r_s = 0.27$, $p < 0.001$ for women), and the results remained the same even after exclusion of low- and high-energy reporters. A higher age was also significantly correlated with a lower energy intake ($r_s = -0.15$, $p < 0.001$ for men and $r_s = -0.13$, $p < 0.001$ for women), and the correlation became stronger after exclusion of low- and high-energy reporters ($r_s = -0.22$, $p < 0.001$ for men and $r_s = -0.23$, $p < 0.001$ for women)

Discussion

Results

The results of this study show that women on average had a somewhat higher eating frequency than men. A higher eating frequency was correlated with a higher energy intake but not with BMI. BMI was not correlated with energy intake. A higher eating frequency was correlated with a higher intake of carbohydrates and fiber, and a lower intake of protein and fats. Correlations with alcohol were weak and differed between men and women.

Eating frequency

The average number of eating occasions was 4.5 for men and 4.7 for women. After excluding low- and high-energy reporters, the average number of eating occasions was somewhat higher, 4.7 for men and 4.9 for women. The difference in eating frequency between men and women was significant, but very small. Several other studies have also found an eating frequency around five meals per day (15, 16, 37-39), and some studies found women to have a somewhat higher eating frequency than men (16, 36, 37). Bertéus Forslund et al. (36, 39) found in their studies that the obese participants more frequently reported an eating frequency of six meals per day, while the reference participants most often reported five meals per day. Women were also found to have a higher number of intake occasions than men. However in their study, no minimal kcal requirement was made for an intake occasion and energy free drinks were counted as an intake occasion. Only a few studies found an eating frequency around four meals per day. These studies were carried out in the US and the study populations were on average overweight (13, 18). These studies used the same criteria to define an eating occasion as this study used.

The studies performed on Swedish populations all found an eating frequency around five to six meals per day. The five meals per day could for example be divided as breakfast, lunch and dinner with two snacks, as it was recommended in the earlier NNR 2004 (41). Although the type of meals has not been examined in this study. Bertéus Forslund et al. (36) has studied snacking frequency among Swedish men and women, and found that obese men had 1.6 and women had 2.0 snacks on average per day outside main meals. The reference men had 1.3 and the women had 1.6 snack on average per day. Snacking outside main meals (breakfast, lunch and dinner) might be a cultural thing (51).

Eating frequency and BMI

No correlation was found between eating frequency and BMI in this study. Several other studies have found an inverse relationship between eating frequency and BMI (4, 13, 14, 16, 18, 37, 40), and many of them have used 15 minutes to part two eating occasions (4, 13, 16, 18). Some of the studies that have shown that a higher eating frequency has been related to a higher BMI have used either one hour to part two eating occasions (15), or asked the participants to specify time of their meals and snacks in an ordinary day in a meal pattern questionnaire (36, 39). The different classifications of an eating occasion pose a challenge to compare the findings of this study to those of others. Some studies have used the same minimal kcal requirement as this study, while others had no minimal energy requirement, and any solid food intake was counted for an eating occasion. The average BMI of the study populations also varies in the different studies. While some studies are based on overweight/obese participants, others have an average BMI around 25.

The method of collecting information about eating frequency differs among the studies. While this study used a four-day food record, most other studies have either used one or several 24-hour recalls, or a meal pattern questionnaire. One 24-hour recall relies on memory, and does not cover day-to-day variations in food intake (52). Also, being interviewed by someone might make the participant want to display a more socially desirable image of their food habits (52). This might be one contributor for the different findings in studies.

This study found no association between eating frequency and BMI and it could be due to the different method used to collect data, weight loss attempts and underreporting of meals (52), and perhaps more health interested participants. However, there may not simply be any association between eating frequency and BMI among the Swedish population.

Energy intake, eating frequency and BMI

Like several other studies (4-6, 15, 21, 37, 39), this study showed a correlation between a higher eating frequency and a higher energy intake. Though it has been hypothesized that a more frequent eating pattern would help control appetite (27-29), it still seems to be associated with a higher energy intake. The results of this study showed no correlation between energy intake and BMI after the exclusion of low- and high-energy reporters. Other studies show conflicting results regarding energy intake and BMI, and underreporting by overweight participants most likely play a role in the inconsistent findings (15, 36, 40). It has been shown that the more the participants under-reported their energy intake, the less frequently they also reported eating (25). This is an important observation to consider since in our study a higher eating frequency was correlated with a higher energy intake, but no correlation was found between eating frequency and BMI, nor BMI and energy intake. It is possible that there is still a great amount of underreporting among overweight participants, and if they reported less eating occasions and a lower energy intake, naturally a higher eating frequency would be correlated with a higher energy intake. This would also explain why eating frequency was not correlated with BMI, since overweight participants tend to under-report more often than normal weight participants (26).

Another explanation for why BMI was not correlated with energy intake could be that people with a higher energy intake are more physically active, and therefore a higher energy intake does not affect their BMI (53). Moreover, this is a cross-sectional analysis and the reported diet may not represent the participant's previous diet. An overweight participant may currently be restrictive with their diet to compensate for the weight they have gained in the past.

Macronutrients

Most studies that have examined the correlation between eating frequency and energy percent obtained from macronutrients have seen an association between a higher eating frequency and a higher carbohydrate intake (4, 5, 37). In this study, a higher eating frequency was correlated with a higher carbohydrate and fiber intake, but a lower fat and protein intake. The same observation was made in a study by Holmbäck et al. (37), and like in this study, they found no association between a higher eating frequency and being overweight. Bertéus Forslund et al. found in their study among obese participants, that an increased snacking frequency was associated with a higher fat intake and a lower protein intake, but not with carbohydrate intake. Another study by Howart et al. (15) noted that skipping a main meal was associated with a higher frequency of snacking, and that the snacks provided the least amount of fiber of all the meals. This suggests that the type of food associated with eating frequency, rather than eating frequency by itself, would be associated with overweight or obesity.

Bellsile et al. (51) in their review of cross-sectional, intervention, and longitudinal studies saw that high fat and sugar snacks had a negative influence on body composition. Irregular snacking, especially in the absence of hunger, seemed to have contributed to weight gain. In a later review, Bellsile et al. (54) noted that snacking in lean individuals did not always increase energy intake. However, in obese individuals it was usually associated with a higher energy intake. Lean subjects had a higher carbohydrate intake from snacks, while the obese subjects had a higher fat intake from snacks. They also noted that obese people tended to have a higher energy intake in the evening, and eat less in the morning. Some of the studies that have found an inverse relationship between eating frequency and overweight/obesity, have noted that skipping breakfast have been correlated with being overweight (16, 18). Unfortunately, the time the meals were consumed was not analyzed in this study.

After the exclusion of low- and high-energy reporters, alcohol consumption was weakly and negatively correlated with a higher eating frequency for women, but no significant correlation was seen for men. Holmbäck et al. (37) and Alijuraiban et al. (16) also noted that a lower eating frequency was associated with a higher alcohol consumption, and a lower consumption of nutrients. They discussed the possibility that less frequent eaters ate out more often and therefore had a higher consumption of alcohol.

In this secondary analysis, the type of foods the participants ate was not analyzed but a higher carbohydrate and fiber intake without increased fat and protein intake could be in the form of vegetables, fruits, and

grains. It is possible that participants with a higher eating frequency may have had healthier food choices, but it cannot be concluded since the types of meals were not analyzed in this study.

Age, physical activity and education

Other studies that have analyzed eating frequency and age have found that a higher age has been associated with a higher eating frequency (15, 37). The same results were seen among the Swedish population, though after the exclusion of low- and high-energy reporters, the correlation was only significant for men. Since in our study energy intake decreased with a higher age and a correlation was seen between eating frequency and energy intake, it could have been assumed that the elderly had a lower eating frequency. This was however not the case. In a study done by Howart et al. (15) it was found that older participants ate more regularly and skipped meals less often than the younger participants. They mentioned that older people more likely ate after a schedule, while younger people tended to skip more main meals and ate more snacks.

A higher age was correlated with a higher BMI and a lower energy intake. Muscle mass decreases with a higher age, and therefore energy expenditure becomes lower (55). Since no correlation was seen between energy intake and BMI, age could partially explain the missing correlation.

Some studies have shown that a higher eating frequency is associated with a higher physical activity level (4, 5, 37), and that this could partially explain why eating frequency was inversely associated with BMI even if it was positively associated with energy intake. No correlation was however seen between eating frequency and physical activity in our study, therefore it is unlikely that physical activity could explain why eating frequency was not associated with BMI in this study.

A higher education has in some studies been associated with a lower BMI and a healthier lifestyle (56, 57), but to my knowledge no study has analyzed the association between eating frequency and education. Since a higher eating frequency was associated with a higher fiber and lower fat intake, and some studies have shown that a higher education would be associated with a healthier lifestyle, it could be assumed that a higher eating frequency would be associated with a higher education. However, after excluding the low- and high-energy reporters there was no statistically significant association between eating frequency and education.

Definition of an eating occasion

Different studies used different definitions of a meal or eating occasion, which makes it difficult to draw any conclusions from the existing research. An eating occasion in this study was defined as an intake of at least 50 kcal and 15 minutes apart from the last eating occasion. This has been recommended by other studies (47,48), since it has shown to be the best predictor in the variance of total energy intake. By using a recommended definition, this study might be more comparable to future studies.

Using a minimal kcal intake of 50 kcal might lead to a lower eating frequency and energy intake for someone who would eat under 50 kcal multiple times in a day. This could have affected the correlations between eating frequency and BMI, and BMI with energy intake. However, going through the data, this was uncommon and most likely would not have affected the results. It is also unlikely that participants would report such small intakes as new meals in the food record.

It is important to bear in mind that this study was an observational study with data collected at only one time point. It is impossible to draw any causal conclusions if eating frequency would lead to overweight or obesity, or if the participant's current energy intake has led to their current BMI. This study has simply observed the correlation between current habits and weight, but cannot conclude if eating frequency would affect BMI or not.

Statistical methods

Baseline characteristics were presented as mean and standard deviation. Since the sample size was big, using the mean as the measure of central tendency was a good way to compare differences between men and women. According to Shapiro Wilks test of normality the data was not quite normally distributed. However, when plotting the distributions in a histogram they were close to being normally distributed, and because of the big sample size independent t-test was used for the comparison of the baseline characteristics. The analyzes were also performed with Mann-Whitney U test to make sure the results were the same, and the same p-values were obtained as with independent t-test. Spearman correlation was used to analyze the correlations, this way no outliers would affect the results. Sensitivity analyses were done on all correlations by excluding low-and high-energy reporters. This was to see if results differed by misreporting.

Low- and high-energy reporters

Of the participants, 325 were excluded as low-or high-energy reporters. The range 0.93-3.18 was used to define under- and over reporters, that Riksmaten 2010-11 had already calculated based on the Goldberg and Black method (49). However, it was still not certain that all under reporting was excluded by using this range. Some participant may have reported a lower than normal energy intake, but not fall under the lower cut-off point for underreporting. The participant would therefore not have been excluded even if they under reported their intake. Therefore the definitions low-and high-energy reporters were used instead of under- and over reporters.

Low energy reporters had a higher BMI, a higher protein intake, and were somewhat younger on average. They also had a lower average eating frequency by one meal per day. Low-energy reporters may not have reported every meal they ate and had therefore a lower energy intake. Holmbäck et al. (37) found in their study that participants with a lower eating frequency (under three meals per day) more often underreported their energy intake.

The exclusion of low-and high-energy reporters did not affect the results a lot, changes from not significant to significant or vice versa in both men and women was only seen in the correlation between energy intake and BMI, as well as between eating frequency and fat intake. The significant negative correlation between energy intake and BMI was likely due to low-energy reporters, since they had a higher BMI on average (44).

Almost two thirds of the low-energy reporters had a lower education, and some studies suggest that under-reporting is more common amongst those with a lower education (52). Low-energy reporters also had a somewhat higher protein intake, which could be the cause of under reporting foods with a negative health image, such as sweets and bakery or other high fat and sugar foods. Bingham et al. noted in their study that under-reporters reported less cakes, sugars and fats, but their protein intake did not differ from others (58).

Strengths and limitations

Some limitations of the study were that the food intake was self-reported, and it is impossible to know how precise participants were with reporting every eating occasion and portion sizes. The participants might have changed their food habits during the study period towards more socially desirable food habits, and therefore their food records might not be representative of their habitual food intake (45, 52). Another limitation was that the participants weight was self-reported, and it cannot be assured that the participants reported their actual weight. The participation was voluntary and therefore it is always a risk that more health-interested people might have taken part in the study. Despite the big study population, the participation rate was fairly low, 36 percent. Looking at the baseline characteristics, mean BMI for the participants was normal weight / on the edge to overweight, and half of the participants were physically active on their leisure time. The study population might not have represented correctly the Swedish population.

Strengths of this study were the large study population that was randomly chosen and distributed all over the country. This increased the chances of getting a representative study population of the Swedish population. The majority of the participants had a BMI between 20 and 30, which decreases the chance of a skewed study population affecting the results. Since participants got different starting days of the week for food recording, every weekday was covered. Weekdays and weekends may look different in regards to food intake. Energy intake and alcohol intake might differ during weekdays and weekends, and many might enjoy

going out for dinner or drinks during the weekends. Even eating frequency might look different during weekends. The food records were also distributed around the year, therefore all seasons of the year were covered.

Another strength of the study was the method used to record dietary intake. Food records have been seen as the most detailed and accurate way to measure food intake (45, 59). Food recording was performed during four days, and the participants were able to record their food intake right after eating. This may have decreased the risk of participants forgetting what they ate. It has been noted that using 24 hour recalls may lead to greater underreporting since people don't remember how much and how often they actually ate. Likewise nibbling between meals is often forgotten this way (52). Food recording during four days does cover more days and therefore might balance out day-to-day variations in food intake.

The Riksmaten method has been validated in two studies, one using double labeled water as biomarker comparing reported energy intake to energy expenditure (45), the other using carotenoids and alkylresorcinols as biomarkers for the intake for vegetable, fruit, whole grain wheat and rye intake (46). The reported energy intake was around 80 percent of the measured energy expenditure. This is however the same degree of misreporting that is experienced with other methods to collect dietary intake (45). Both studies concluded that the Riksmaten method is able to satisfactorily capture food intake.

Conclusion

The results of this study showed that eating frequency was not correlated with overweight/obesity among Swedish men and women. Energy intake was not correlated with BMI, but was positively correlated with eating frequency. A higher eating frequency was correlated with a higher carbohydrate and fiber intake, and a lower protein and fat intake.

The results suggest that eating frequency and energy intake are not the major determinants of BMI in this study. Misreporting, despite the exclusion of low- and high-energy reporters, might however be a reason for not seeing a correlation between eating frequency and BMI, and BMI and energy intake. Out of these results it cannot be concluded that a higher eating frequency contributes to overweight, but it seems to lead to a higher energy intake. Perhaps recommendations about meal patterns should not be generalized, but individualized, and the most important aspect is to focus on food choices. Since this was a cross-sectional study, any conclusions about cause and effect cannot be drawn.

Future studies should agree on using one set definition for an eating occasion. Future studies done on eating frequency should also evaluate the type of foods eaten. Longitudinal and interventional studies should be made to find if eating frequency does affect BMI.

My contribution

The Swedish National Food Agency has created the method and collected the data for Riksmaten 2010-11. They have also provided me with the dataset, where the number of eating occasions for every participant was already calculated. My work has been to statistically analyze data from baseline and look into eating frequency and its correlations, something that was not done in Riksmaten 2010-11. I want to thank Anna-Karin Lindroos, who has guided and helped me throughout the making of this thesis.

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