Stability of meal frequencies and exploration of the relationship between breakfast consumption and BMI from age 14 to 30 in the Norwegian Longitudinal Health Behaviour study

Master Thesis by
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http://www.duo.uio.no/
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This thesis is written on data from the Norwegian Longitudinal Health Behaviour (NLHB) study that was started by the Research Center for Health Promotion (HEMIL-senteret) in 1990. First, I want to give a word of thank you for the groundwork laid down by the staff at the Research Center for Health Promotion that enabled me to write this thesis. Furthermore, the participants in this study deserve a big thank you for taking the time to fill out the questionnaire at several occasions.

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Summary

**Background and aims:** The global epidemic of overweight and obesity is a major public health problem since obesity is associated with an increased risk of several chronic diseases, such as coronary heart disease, ischemic heart disease, diabetes type 2 and some types of cancers. Also, being overweight/obese in adolescence has been shown to increase the likelihood of being overweight/obese in adulthood. Many factors have been hypothesized to influence weight development, and lately a much debated factor has been meal frequency, and especially breakfast consumption. Both total meal frequency and breakfast consumption have been found to be cross-sectionally associated with lower body mass index (BMI) among adolescents. The potential benefits of breakfast consumption in adolescence on body weight outcomes (e.g. BMI) later in life are based on some assumptions like stability of consumption over a longer period of time. One way to investigate the stability in breakfast consumption by age is to perform tracking analyses. To perform such analyses, longitudinal studies are a necessity. Longitudinal studies on the association between breakfast consumption and body weight outcomes in adolescents are still scarce. In this thesis this issue is illuminated in a prospective cohort study. The overall aim was to describe development in frequency of the main meals from the age of 13 to 30 years, and to explore the relationship between consumption of breakfast and BMI longitudinally.

**Design:** The Norwegian Longitudinal Health Behaviour (NLHB)-study is a prospective two-generational cohort study over 17 years where the adolescents were surveyed at 9 occasions from age 13 in 1990 to age 30 in 2007, and their parents were surveyed at 3 occasions, in 1990, 1993 and 1996.

**Sample and methods:** Of the 1170 invited 7th graders from Hordaland County, 924 (78 %) participated at baseline. Data were collected by self-administered questionnaires, first through schools and later by regular mail. The questions used in this thesis are primarily meal frequencies of the 4 main meals, weight and height, hours/week spent on physical activity, and a measure of parental education based on a combination of parent and adolescent reports. One-way analyses of variance (ANOVA) /chi-square tests were used to compare gender differences in frequencies/proportion of daily consumers of the meals. Change by age in consumption of the meals was evaluated by the 95 % confidence intervals of the mean
frequencies at the different ages. Stability in breakfast consumption was evaluated by whether the adolescents kept their relative position at later ages based on a division of the frequency of consumption into three levels at age 14. Differences in mean BMI between daily and non-daily breakfast consumers were evaluated by ANOVA-analyses. Multiple regression analyses were performed on the relationship between breakfast frequency at baseline (age 14 or 19) and BMI at age 30. The latter analyses were stratified on physical activity level (low/high) at baseline, and adjusted for parental education, gender and BMI at baseline (age 14 or 19).

**Results:** An initial decrease by age in consumption of meals was observed for both genders, followed by an increase in young adulthood. Generally males consumed meals more frequently than females. The level of breakfast frequency was found to “track” from the age of 14 and up until the age of 30 for both genders. Cross-sectionally no differences were found between daily and non-daily consumers of breakfast. Longitudinally, daily consumer of breakfast seemed to have a lower BMI compared to non-daily consumers (some significant and some non-significant differences). This was found in almost all groups after stratifying on gender and weight status at baseline (age 14 or 19), and both when applying breakfast consumption at age 14 or 19 as baseline. The exception was in normal weight females when using breakfast at age 19 as baseline, where the tendency was opposite. Adjusting for gender, parental education and baseline BMI, higher breakfast frequencies at baseline were found to be associated with lower BMI at age 30, but only in groups of low physical activity.

**Conclusion:** The decrease by age in meal consumption, particularly regarding breakfast, might be a concern considering evidence of possible health benefits from consuming breakfast. The finding of a relative stability by age between different levels of breakfast consumption at age 14, indicate that breakfast habits are formed early. The association between daily/non-daily breakfast consumption in adolescence and BMI at later ages, did not seem to differ by weight status at baseline (age 14 or 19) in this thesis. However, the multiple regression analyses, did indicate that the importance of consuming breakfast in adolescence on BMI later in life, might vary by the level of physical activity, with low physical activity groups being the ones that benefit from it. More longitudinal studies confirming the findings in this thesis are needed. Also, qualitative studies are required to explore how breakfast habits are established, and to understand the gender differences and change by age in breakfast consumption.
Norsk sammendrag


Utvalg og metoder: Av de 1170 inviterte 7. klassingene fra Hordaland fylke, deltok 924 (78 %) i den først datainnsamlingen. Data ble samlet inn ved selvadministrerte spørreskjemaer, først i skoletiden og senere via vanlig post. Spørsmålene som har blitt brukt i denne masteroppgaven, er hovedsakelig måltidsfrekvenser for de 4 hovedmåltidene, vekt og høyde, fysisk aktivitet (timer/uke), og et mål på foreldrenes utdannelse basert på en kombinasjon av svar fra foreldre og ungdommer. Enveis variansanalyser (ANOVA)/kjø-kvadrat tester ble brukt for å undersøke kjønnssforskjeller i frekvens/andel dagligspisere av måltidene. Endring med alderen i konsum av måltidene ble vurdert ved 95 % konfidensintervaller for gjennomsnittlig konsumfrekvens ved de ulike aldre. Stabilitet i frokostkonsum ble vurdert ved om ungdommene beholdt sin relative posisjon ved senere aldre, basert på en inndeling av konsumfrekvensen i tre nivåer ved 14 årsalder. Forskjeller i gjennomsnittlig KMI mellom
daglig- og ikkedagligspisere av frokost, ble evaluert ved ANOVA-analyser. Multiple regresjonsanalyser ble utført for forholdet mellom frokost ved utgangspunktet (14 eller 19 år) og KMI ved 30 år. De sistnevnte analysene ble stratifisert på nivå av fysisk aktivitet (lav/høy) ved utgangspunktet (14 eller 19 år), og det ble justert for foreldrenes utdannelse, kjønn og KMI ved utgangspunktet (14 eller 19 år).


**Konklusjon:** Nedgangen i inntak av måltider med alderen, særlig når det gjelder frokost, kan være av bekymring med tanke på mulige helsefordeler ved å spise frokost. Den relative stabilitet med alderen mellom ulike nivåer av frokostkonsum ved 14-årsalder, viser at frokostvaner dannes tidlig. Assosiasjonen mellom daglig/ikke-daglig frokostspising i tenårene og KMI ved senere eldre, så ikke ut til å variere med vektstatus ved utgangspunktet (alder 14 eller 19) i denne masteroppgaven. De multiple regresjonsanalysene indikerte imidlertid at viktigheten av å spise frokost i tenårene for KMI senere i livet kan variere med nivået av fysisk aktivitet, hvor grupper med lav fysisk aktivitet ser ut til å være de som kan dra nytte av det. Det er behov for flere longitudinelle studier som bekrefter funnene i denne masteroppgaven. Det er også behov for kvalitative studier for å forklare hvordan frokostvaner etableres og for å forstå kjønnsforskjeller og endring med alder i frokost inntak.
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## Abbreviations

<table>
<thead>
<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
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<tr>
<td>GEE</td>
<td>General Estimation Equation</td>
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<tr>
<td>The HBSC-survey</td>
<td>The Health Behaviour among School-aged Children survey</td>
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<tr>
<td>KMI</td>
<td>Kroppsmasseindeks</td>
</tr>
<tr>
<td>The NLHB-study</td>
<td>The Norwegian Longitudinal Health Behaviour study</td>
</tr>
<tr>
<td>SES</td>
<td>Socio-economic status</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>95 % CI</td>
<td>95 % Confidence Interval</td>
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1 Introduction

1.1 Scope

This thesis is part of a research project that aims at investigating individual and environmental factors’ influence on weight development from adolescence to adulthood, and also, whether these vary by socio-economic status (SES) and gender. The reason for wanting to illuminate these relations, is to better inform interventions and policies that can reduce the burden of the ongoing obesity epidemic on public health. Many factors have been hypothesized to influence weight development, and one of the most debated factors recently has been meal frequency, and especially breakfast consumption. The scope of this thesis was to explore the dataset from the cohort study that the main project will be applying, to illuminate possible gender and social differences in meal frequencies and thus get a picture of what the data holds regarding these topics. As a second part of the exploration, the meal frequency (specifically breakfast frequency) was investigated in relation to weight development from adolescence to young adulthood. The findings in this thesis will serve as a guiding in the main project, as to what it would be of interest to investigate in depth, in terms of meal/breakfast frequency being a possible determinant of weight development, and also the associations with gender and SES.

1.2 Background

1.2.1 The obesity epidemic

The worldwide epidemic of overweight and obesity is a major public health problem prevalent in both high and low income countries affecting children and adults alike (1). The World Health Organization (WHO) estimated that in 2005, more than 1 billion people globally were overweight (BMI ≥ 25) and more than 300 million were obese (BMI ≥ 30) (2). In some countries the obesity prevalence seems to be levelling-off (3-5), this also in the disadvantaged groups. Even though there seem to be a levelling-off in the obesity prevalence in all groups (5), obesity has been shown to still be more prevalent in less advantaged groups (4). The levelling-off in obesity prevalence may, in some cases, be explained by an already high obesity prevalence; but in other cases it might be that the national public health efforts have started to show a promising effect. Despite the levelling-off demonstrated in some
studies, rates of overweight and obesity are projected to increase in almost all countries, causing 1.5 billion people to be overweight in 2015 (2).

Europe is one of the regions with the highest mean BMI, together with the Americas and the Eastern Mediterranean (6). In the report “The challenge of obesity in the WHO European Region and the strategies for response” (7) the prevalence of overweight among adults ranged between 32 % and 79 % for men and between 28 % and 78 % in women over the different countries in the European region. The prevalence of obesity ranged from 5 % to 23 % among men and between 7 % and 36% among women. The Health Behaviour among School-aged Children (HBSC) -survey from 2005 (8) showed that prevalence of adolescents reporting to be overweight or obese among 11, 13 and 15-year olds vary considerably between countries, ranging from 6 % (Netherlands and Switzerland) to 29% (the United States) among the 11 year olds, from 6 % (Lithuania) to 31 % (Malta) among the 13 year olds, and from 6 % (Lithuania, Romania) to 30 % (Malta) among the 15 year olds. In the same survey family affluence was found to be associated with overweight and obesity in about half of the countries and those from less affluent families were more likely to be overweight or obese. Furthermore, boys reported higher levels of overweight and obesity in about half of the countries at age 11 and in most countries at ages 13 and 15 compared to girls. In a survey conducted in 2005-2006 (9) on a national representative sample of Norwegian 9- and 15-year olds, objective measures of height and weight were obtained; 14.7 % and 4.7 % of the 9 year old girls were overweight and obese, and 12.8 % and 2.8 % of the 9 year old boys were overweight and obese, respectively. For the 15 year olds, 11.6 % and 1.3 % of the girls were overweight and obese, and 9.2 % and 4.4 % of the boys were overweight and obese, respectively.

Health concerns regarding high prevalences of overweight and obesity are related to the associated increased risk of several chronic diseases, such as coronary heart disease, ischemic heart disease, diabetes type 2 as well as the risk of some types of cancers (breast, colon, prostate and others) (6). A review of longitudinal studies showed that childhood and adolescent overweight/obesity seem to track into adulthood (10). Thus the health concerns for the overweight/obese adult population also affect the overweight/obese younger population in the long run, and therefore primary prevention of overweight/obesity or prevention of its persistence from childhood/adolescence into adulthood is important for public health.
The fundamental cause of overweight and obesity is an energy imbalance, where calories consumed exceeds the calories expended over time (11). There are, however, many factors affecting this energy balance. It is clear that genetic factors are important in determining body weight (12). However, also behavioural and environmental factors contribute to different degrees. In the Expert Report “Food, Nutrition, Physical Activity and the Prevention of Cancer: a Global Perspective” (13) the World Cancer Research Fund International examined different factors that might affect the risk of weight gain, overweight and obesity. Regular and sustained physical activity is there listed to convincingly reduce risk and a sedentary living to convincingly increase the risk. Low energy-dense foods are listed to probably reduce the risk, while energy-dense foods, sugary drinks, fast foods and television viewing are listed to probably increase the risk.

Recently, there has also been increasing interest in how meal frequency (14) – and especially breakfast consumption (15) – may reduce the risk of overweight/obesity. The proposed mechanisms through which increased meal frequency may influence weight development is that it might result in enhanced control of appetite (16-18), possibly through an prolonged and attenuated insulin response, but release of gut hormones (17;18) and gastric stretching (17) has also been suggested to possibly be involved. Proposed mechanisms especially for breakfast consumption are that dietary fibre (which are often consumed in breakfast meals), may positively influence weight development through hormonal, intrinsic and colonic effects that might give increased satiety and satiation, decreased energy intake, increased fat oxidation and reduced fat storage (19). In addition, a study indicated that the time of the day that foods are consumed might influence appetite and total energy intake (20), with results implying that intake of food in the morning might be particularly satiating, and that it might result in a reduction of the total energy amount consumed during the day. It should be noted that studies on mechanisms are still scarce, so more research is needed to confirm the hypotheses and their possible contribution to understanding the development of overweight.

A recent review on breakfast consumption and body weight outcomes in children and adolescents in Europe, showed that breakfast consumption consistently was associated with overweight and obesity (15). Even though the review search was not restricted to cross-sectional studies, no longitudinal nor experimental studies were included. This, mainly illustrate the lack of longitudinal and experimental studies on breakfast consumption in relation to weight development in children and adolescents.
1.2.2 Breakfast and weight development

Regardless of a possible beneficial effect of breakfast on weight development, it is important to keep in mind that breakfast often is referred to as the most important meal of the day for other reasons as well. These reasons include health related outcomes such as higher dietary quality and nutritional adequacy associated with breakfast consumption in adolescence (21-23), as well as studies showing that breakfast consumption may positively benefit cognitive functions related to memory, academic performance and school attendances (24). Breakfast skipping on the other hand, has been associated with impaired academic performance and mental distress among adolescents (25). Despite the increasing evidence of several health benefits of breakfast consumption, breakfast has been found to be the most omitted meal of the main meals (26). The trend seems to be that of increased breakfast skipping both with time (secular trend) and with age in adolescents (27,28). The potential benefits of breakfast consumption and detrimental effects of skipping it are, however, based on some assumptions like stability of these behaviours for a longer period of time.

To study tracking and stability of variables over time, a longitudinal study design is a necessity. In epidemiologic literature, tracking is used to describe the relative stability of the longitudinal development of a certain outcome variable (29,30). Even though there is no single definition of tracking, there are some key concepts involved. These have been summarized by Twisk et al (29): “1) the relation/correlation between early measurements and measurements later in life or the maintenance of a relative proportion within a distribution of values in the observed population through time, or in other words, the longitudinal stability of a certain variable,” and “2) the predictability of future variables by early measurements.” A measurement “tracks” if there is a positive relation over subjects between two or more time points. High degree of tracking indicates that people keep their relative position in a given variable over time (e.g. those consuming breakfast most frequently in adolescence, also consume breakfast most frequently at subsequent time points compared to those consuming breakfast less frequently in adolescence). Low degree of tracking indicates that there is no such systematic pattern over time.

Those prospective studies that have examined the associations between breakfast habits and body weight in adolescents report an inverse association between breakfast intake and BMI (31-36). The 6 articles referred to are, however, written on a total of 4 studies, all of which are conducted in the U.S. Niemeier et al. (34) and Merten et al. (35) both apply data from the
National Longitudinal Study of Adolescent Health, but with some differences in objectives and statistical methods used. Such differences are also the case for Affenito et al. (33) and Albertson et al. (36) which both apply data from the National Heart, Lung and Blood Institute Growth and Health Study. In the latter mentioned study, a biracial cohort study following girls from the age of 9 to 19, Affenito et al. (33) found that more consistent breakfast consumption (more days), was predictive of a lower BMI in models that adjusted for basic demographics (i.e. site, age, and race). However, when additionally adjusting for parental education, energy intake, and physical activity, breakfast no longer had an independent effect on BMI. In prospective analysis of breakfast frequency and 5-year body weight change in the Project Eating Among Teens cohort of 2216 adolescents, Timlin et al. found that frequency of breakfast consumption (days/week) was inversely associated with BMI change in a dose-response relationship (31). Adjustment for several confounders and dietary factors did not seem to explain the association. However, adjustment for weight-related variables such as dieting and weight concerns partially explained the association. An interesting finding is that of Berkey et al. (32) that reported breakfast to be associated with overweight when analyses were performed cross-sectionally. However, in the same study overweight children who never ate breakfast decreased their BMI the following year (longitudinally) compared to overweight children who ate breakfast nearly every day. Normal weight children who did not eat breakfast on the other hand, tended to gain weight compared to those who ate breakfast routinely (though not significant), suggesting that the importance of eating breakfast from a weight perspective might vary by weight status. This variation of importance is also supported by a study by Alberson et al. (36) that followed a female cohort from the age of 9 to 19, even though somewhat incompatible with the findings of Berkley et al (32). Alberson et al. (36) reported that eating breakfast more frequently was associated with lower BMI at the end of the study. It was, however, only found among females with relatively high BMI at baseline.

Even though not all studies support an association between breakfast consumption and weight (37;38), there seem to be an preponderance of studies supporting that eating breakfast regularly is associated with a lower risk of becoming overweight or obese. This could, however, be partly due to publication-bias. In any case the evidence body is still more scarce in the longitudinal studies, especially studies following the adolescents all the way from early teenage years and into young adulthood, and through the transitional stages that this encompasses. It is also important to notice that the studies mentioned above are observational, thus, causality should not be assumed on these findings. Also, as concluded in a recent review
by Pereira et al. (39), there is a need for studying the content of the breakfast meal when investigating breakfast eating/skipping in relation to overweight. It follows from this that there is a need for both longitudinal cohort studies and intervention studies, as well as experimental studies on meal and breakfast frequency in relation to weight development in adolescents.

Because of the threat to validity, it has been stressed by others that any study that evaluates breakfasts effect on the risk of overweight and obesity should attempt to statistically adjust for confounding factors (15). Commonly considered confounders in the relationship between breakfast eating and overweight or obesity, are parental obesity, birth weight, dietary factors, physical activity, socio-economic status, age and sex (15). It is important to be aware of this and adjust for confounding when possible, this because it has been found that adjusting for several confounding factors leads the analyses on breakfast in relation to weight measures to become not statistically significant (31;33).

A variety of definitions have been used to characterize breakfast consumers in different studies, including eating breakfast every day, every school day, on the dietary survey day, a minimum number of days per week, or usual or habitual consumption (24). Similarly, different definitions of breakfast skippers have also been used in different studies (15). These inconsistencies present a challenge when evaluating and comparing studies. Also, different definitions have been used on defining overweight and obesity in the different studies (40;41).
2 Aims and research questions

In this thesis it is attempted to illuminate in a longitudinal study, issues of meal frequencies, in particular breakfast, and weight development that so far primarily have been studied in cross-sectional studies. The overall aim was to describe the development in meal consumption and explore the relationship between breakfast consumption and BMI longitudinally. There are thus two parts of this overall aim and they are further specified in research questions below.

PART I. How is the development in frequency of consumption for the different meals from adolescence to adulthood?

Are there changes in consumption (absolute change) of the different meals from the age of 13 to 30?

Are there gender differences in consumption of the different meals at any age?

Do the frequency of consumption of breakfast exhibit rank stability? (relative stability)

PART II. Is breakfast consumption in adolescence related to BMI in adulthood?

Is daily breakfast consumption associated with BMI cross-sectionally at ages 19, 21, 23 and 30 when stratified on gender?

Is daily breakfast consumption in early and late adolescence associated longitudinally with BMI?

Is breakfast consumption in early and late adolescence associated with BMI at age 30, when adjusting for potential confounders?
3 Methods

3.1 Study design

The Norwegian Longitudinal Health Behaviour study (NLHB) is a prospective cohort-study focusing on aspects of health behaviour, lifestyle and self-reported health of adolescents as they enter young adulthood. The study was directed from the Research Center for Health Promotion (HEMIL-senteret) at the University in Bergen, and the data collections took place in the fall in the years from 1990 to 2007. The participants were surveyed at 9 time points (ages 13, 14, 15, 16, 18, 19, 21, 23 and 30) in the 17 years. In addition, the male and female parent/guardian of the adolescents were surveyed when the adolescents were 13, 16 and 19 years old (42). The rationale behind the study was the need for longitudinal, analytical studies with an epidemiological perspective in order to meet the foreseen demand for evidence and theory based input to the field of health promotion and disease prevention in the years ahead (43).

3.2 Data collection and sample

The study was conducted in Hordaland County, Norway. All schools in the county with 7th grade classes were eligible for inclusion. None of the 22 randomly chosen schools declined the invitation (44). Written consent from the adolescent and the parent/guardian was collected before the first survey and was required for the adolescents to participate in the study. The data were collected by self-administered pen and paper surveys in September/ October at each data collection. However, at the last data collection (age 30), the participants could chose between pen and paper survey, and directly answering over the internet – the proportion that made use of the latter alternative was 26.4 %. Professionally trained researcher staff administered the data collections during school hours at ages 13, 14, and 15. The subsequent surveys (age 16-30) were sent to the participants by regular mail. The surveys at ages 13 and 15 were especially long (2 x 45 min) compared to the rest. Whereas, the survey at age 16 was especially short, this to encourage the adolescents to continue to participate also when the surveys were mailed to their home. In order to reach as many subjects as possible, newsletters and request for updates on new addresses were sent to the participants’ last known address a few months prior to the next data collection. The study initially got permission and support
from educational boards at every level from the ministry to the local schools (45). The study was approved by the Norwegian Data Inspectorate and was conducted in full accordance with ethical principles, including the provisions of the World Medical Association Declaration of Helsinki. The Research Centre for Health Promotion (HEMIL-senteret) has been responsible for data collection, production and quality control of the data files throughout the study.

Of the 1170 boys and girls that were invited from the 22 schools, 924 (78 %) subjects participated in the baseline survey. Of the 263 adolescents not participating, 222 could not be surveyed due to lack of written consent from parent/guardian, and 41 of the adolescents did not want to participate. Also, 3 individuals were excluded because of incomplete forms at baseline. The initial study population is believed to be representative of adolescents of the same birth cohort in Hordaland (46). At baseline 648 fathers and 735 mothers participated, representing 70 % and 80 % of the baseline sample of the adolescents, respectively.

3.3 Research instrument

The questionnaire used in this study was developed based on theories and the questionnaires previously used by the WHO in their cross-national study: Health Behaviour among School-aged Children (HBSC) (47-50) and the Bergen Nutrition Education study (51). A one-week test-retest reliability study was performed on a subsample (n=80) of the adolescents at age 14. In addition, a similar study was performed in Oslo among adolescents aged 17-19 years, for a subsample of the questions used in the NLHB-questionnaires at ages 16, 18 and 19 (52).

3.3.1 Meal consumption data

The meal consumption data was collected as frequency questions for the different meals; “Within a week, how often do you usually eat these meals?” The meals inquired about were breakfast, lunch, sandwiches after school, snacks after school, dinner and supper. In this thesis the four main meals; breakfast, lunch, dinner and supper are included. These meals were inquired about at every data collection except for at age 16. The four response categories for the meals were (recoded values in parentheses): “daily” (7 times/week), “4-6 times/week” (5 times/week), “1-3 times/week” (2 times/week) and “seldom or never” (0.5 times/week). The answer categories indicate an underlying continuous variable, hence the recoding into a variable that can be used as continuous variable.
For the statistical analyses that use the variable daily consumers/non-daily consumers of the different meals, the question on frequency of consumption was recoded into “daily” = 1 versus the rest = 0.

### 3.3.2 Indicators of weight and height, BMI and overweight

Weight (kg) and height (cm) were self-reported at all time points. Questions on weight and height were included at every data collection except for omission at age 16.

Body mass index (BMI) (kg/m²) was calculated for all time points from the age of 18, for males and females separately. Overweight and obesity are described by WHO as “abnormal or excessive fat accumulation that may impair health” (11). BMI is commonly used to determine overweight and obesity in adults; BMI ≥ 25 kg/m² is defined as overweight, and BMI 30 ≥ kg/m² is defined as obesity (11). The BMI-variable was in this thesis dichotomized into normal weight (BMI < 25) and overweight, including obese subjects (BMI ≥ 25), recoded into 0 and 1, respectively. The dichotomized variable was used to determine the prevalence of overweight at the different ages.

Mean BMI was also calculated for the age of 14. Therein age and sex specific cut-off values that allow for the intended growth and development in children and adolescents, as suggested by the International Obesity Task Force (40), were used to determine the prevalence of overweight (including obesity); the cut-off values being 22.62 (kg/m²) and 23.34 (kg/m²) for males and females, respectively.

At age 30 years, five individuals reported their height to be 2 cm. Furthermore, at age 14 one individual reported to be 209 cm high and having a weight of 27 kilograms, suggesting a BMI of 8.6. Because of the biological impossibility of these data, and because of their impact on the data analyses, they were removed from all analyses that were based on the height and weight variables.

### 3.3.3 Other variables included in the analyses: Potential covariates, confounders and moderators

In addition, parental education, physical activity and dieting were tested for inclusion in the multiple regression analyses to explain variation in BMI. In the multiple regression analyses it
would be preferable to adjust for energy intake as well, however, the variables measured in this study are not able to give a good estimate of the energy intake of the participants.

**Gender**

Gender was measured by self-report, and the baseline report was used in all the data analysis. For the statistical analyses males were coded as 1 and females as 2.

**Parental education**

The parents were asked about their highest level of education in the 1996- survey (when the adolescents were 19 years old). The question asked was: “How many years of education do you have?” The answer categories were: No education beyond 9 years of mandatory school; 1-2 years of upper secondary school; 3 years of upper secondary school; College/university, less than 4 years; College/university, 4 years or more; Others. If both parents participated in the survey and answered the question on education, the parent reporting the highest level of education was chosen for the analyses. This variable was used as an indicator of the parent’s SES, and hence an indicator of the adolescents SES, but there was 56.8 % missing on this variable (i.e. the parents’ combined answers).

Because of a fair agreement between parents’ reports on own education and adolescents’ reports on their parents’ education (53), the analyses in this thesis included the adolescents’ reports on parental education if both parents’ reports were missing, this to reduce the loss of subjects included. The adolescents were asked the following question at age 15: “How much education do you think your father/mother has?” The answer categories were: Elementary school (7 years); Secondary school (9 years); Manual education; Office/trade education; Gymnasium; Less than 4 years of university/higher education; More than 4 years of university/higher education; Other education. Again, if the adolescent answered on the question on their parents’ education for both parents, the parent reported to have the highest level of education, was chosen for the analyses. This approach of combining parents and adolescents reports to solve the problem of missing subjects, due to missing data, has been used previously in this study (54).

One way ANOVA-analyses showed that BMI at age 30 (as the dependent variable) was distributed dichotomously in relation to parental education (results not shown). The low and
middle parental education-groups had higher mean BMI at age 30 than the high parental education-group. Analyses also showed that breakfast consumption was dichotomously distributed in relation to parental education (results shown in Appendix I). This justifies dichotomizing the parental education variable in the multiple regression analyses, collapsing low and middle parental education and keeping high parental education as a separate category. For the statistical analyses the categories were coded as 1 (low/middle) and 2 (high).

Further information on the combination of parents’ and adolescents’ answers on parental education and the collapsing of categories can be found in Appendix I.

Physical activity

The physical activity of the adolescents was measured by the following question: “Outside school hours, how many hours per week do you do sport or exercise until you are out of breath or sweat?” The response categories were: 7 hours/week or more; about 4-6 hours/week; about 2-3 hours/week; about 1 hour/week; about ½ hour/week; none. This question was included in all the data collections, although, when the participants were 16 years of age and graduated from mandatory school, and forward, the phrase: “Outside school or work hours,...” was used. In the analyses these answers were dichotomized into those who exercised ≥ 2-3 hours/week (coded as 1) and those who exercised < 2-3 hours/week (coded as 0).

Dieting

The adolescents’ dieting habits were measured by the following question at age 21: “Have you ever tried to diet?” The answer categories were: Yes, many times; Yes, sometimes; Yes, once; No, never. For the analyses testing dieting as a potential confounder, the variable was collapsed into two categories as follows: Yes, many times/Yes, some times (coded as 1) vs. Yes, once/No, never (coded as 0).
3.4 Test-retest reliability

The one-week test-retest study performed at age 14 had the following kappa coefficients: $\kappa = 0.81, 0.65$ and $0.60$ for the question on breakfast (daily), lunch (daily) and dinner (daily), respectively (42). In the test-retest study performed among 17-19 year olds in Oslo in the spring of 2000 (52) the kappa coefficients for breakfast, lunch and supper were 0.71, 0.54 and 0.63, respectively, and the Pearson’s correlation coefficients were 0.90, 0.76, 0.75 and 0.78, for breakfast, lunch, dinner and supper, respectively. That latter study tested reliability only for the frequency of consumption of the different meals, with four answer categories included.

3.5 Statistics

The statistical software SPSS (version 16.0) was used in all the statistical analyses. Statistical significance was set to $P \leq 0.05$ unless otherwise specified. Also, if otherwise not specified, the term “significant” will from here on forward be used synonymously with “statistically significant”.

For parametric techniques, it is assumed that the populations from which the samples are taken are normally distributed. The Kolmogorov-Smirnoff test of normality, histograms, and Normal Q-Q Plots were used to assess the variables normality. As the results of the Kolmogorov-Smirnoff tests are affected by sample size (large sample sizes may lead to a false conclusions of non-normality), the histograms and the Normal Q-Q Plots were weighted as more important when evaluating normality. Whenever the number of participants was large enough ($n \geq 30$) (55), parametric tests were performed despite of non-normality, this in accordance with the central limit theorem (56). One-way ANOVA make the assumption that samples are obtained from populations of equal variance. Therefore, Levene’s tests were performed to confirm this assumption. Whenever the assumption of homogeneity of variance was violated, results from Welsh or Brown-Forsythe tests (whichever gave the highest p-value) were presented instead of the ANOVA-results. If >2 groups were compared in the ANOVA, Bonferroni post hoc tests were performed to investigate differences between the specific groups. For the categorical data where chi-square tests were performed, all cells had expected counts well above the recommended ($>5$).
3.5.1 Gender differences in breakfast consumption

Descriptive statistics were used on cross-sectional data to determine the mean frequency of consumption of the different meals (frequency/week) and to determine the prevalence of daily consumers of the different meals.

The mean frequency of consumption of the different meals was tested for gender differences by one-way ANOVA, and the 95 % confidence intervals (CI) from these analyses were used to evaluate change by age (overlapping 95 % CIs indicating no change). Gender differences in proportion of daily consumers of the different meals were investigated by performing chi-square tests.

3.5.2 Tracking analyses

The tracking analyses were done separately by gender. This stratification was motivated by the gender differences in breakfast consumption found in the cross-sectional analyses in this thesis, and by reports of similar findings among adolescents in other studies (22;27;35;57). Pooled estimates would thus not be representative for either males or females.

Because 225 participants did not reach to complete the questionnaire in the allocated time at age 13, the data from the survey at age 14 were used as baseline in the tracking analyses – representing 96 % of the participants at age 13 and 74 % of the invited cohort.

For the tracking analyses, the participants were divided into three groups according to the frequency of breakfast consumption at age 14: “≤ 1-3 times/week”, “4-6 times/week” and “Daily”. One-way ANOVA were performed to study the difference in mean frequency between the groups, and their relative positions at subsequent time points.

3.5.3 Weight and height

Descriptive statistics were used to determine the mean height, weight and BMI, as well as to determine the proportion of overweight subjects. To evaluate differences in mean BMI and proportion of overweight by gender and age, 95 % CI were used (overlapping 95 % CIs indicating no difference).
3.5.4 Breakfast consumption and BMI

First, one-way ANOVA were performed to cross-sectionally compare mean BMI of daily and non-daily consumers of breakfast at ages 19, 21, 23 and 30.

In the longitudinal analyses comparing mean BMI at subsequent time points between daily and non-daily consumers at baseline, ages 14 and 19 where chosen as baseline. The analyses were first performed in males and females separately, and then further stratified by both gender and weight status at the baseline in question. At age 14 there were, however, too few overweight individuals to do a comparison of the mean BMI (between daily and non-daily consumers) at subsequent ages. One-way ANOVA was also used in the longitudinal analyses to compare the mean BMI in daily and non-daily consumers of breakfast. In these analyses, some of the groups at some time points had a smaller number of subjects than recommended (n < 30) for performing ANOVA-analyses (55). In those cases, both the parametric (one-way ANOVA) and the non-parametric alternative (Mann-Whitney U tests) were performed. Because the two alternatives gave the same results, in terms of significance and direction of difference, the results from the one-way ANOVA are presented for all time points and all groups.

3.5.5 Multiple regression analyses: Breakfast consumption and BMI at age 30.

In the multiple regression analyses, BMI (continuous) at age 30 was the dependent variable, while breakfast consumption (continuous) was the independent variable of primary interest. The multiple regression analyses were done twice, one where the independent variables were taken from the adolescents’ reports at age 14 years, and one with independent variables from age 19. Those two models will from here on forward be referred to as the “Age-14 model” and the “Age-19 model”, respectively.

In addition to the variables that were tested for inclusion in the models, the “Age-14 model” and the “Age-19 model” were also run with BMI from age 14 and 19 as independent variables, respectively, to investigate if the association of breakfast consumption and BMI persisted when earlier BMI was controlled for and to see how it influenced the proportion of variance explained ($R^2$).
On the basis of literature (15) and knowledge of variables that might affect the relationship between breakfast and BMI, and also on the basis of the prior findings in this thesis, the variables “dieting” (dichotomous), “gender”, “parental education” (dichotomous), “physical activity” (continuous) and “BMI at an earlier time point” (continuous) were tested for inclusion in the multivariate models. Preliminary analyses included correlation-matrices between these variables and also breakfast consumption. The matrices were done in two turns, were the independent variables were taken from the adolescents reports at age 14 and 19, respectively. Both Pearson’s and Spearman’s correlations were performed, but there were no substantial differences in the results. (Pearson’s correlation matrices can be found in Appendix II). As none of the correlation coefficients were > 0.7, all the variables were further tested for being possible covariates, confounders or mediators. The results from these testings are shown in the results chapter. The method of testing is, however, further explained here.

The variables were tested for inclusion as confounders, covariates or moderators (Figure 1). These are all third variables that influence the associations between independent (i.e. breakfast consumption) and dependent (i.e. BMI at age 30) variables (58).

A moderator is a variable that affects the strength or direction of the relation between two variables. Moderator is usually an interaction, that is, the relationship (c in Figure 1) between X (i.e. breakfast consumption) and Y (i.e. BMI at age 30) depends on a third variable (i.e. physical activity) (58).

A confounder causes both X (i.e. breakfast consumption) and Y (i.e. BMI at age 30), so ignoring the confounder leads to an incorrect inference about the relationship (c in Figure 1) between X and Y (i.e. the effect of breakfast consumption is mixed together with the effect of another third variable, leading to bias) (58). The effect of breakfast would be confounded to an extent that depends on the strength of the relationship between breakfast and that third variable (b in Figure 1) (59).

A covariate is a variable that is related to X and/or Y, and improves the prediction of Y by X. Because it is related to the dependent variable it reduces unexplained variability in the dependent variable. A covariate is similar to a confounder but it does not appreciably change

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1 In practice, a confounder could also be a proxy or a marker for a cause of the outcome.
the relation between X and Y (c in Figure 1), hence it is related to X and Y in a way that does not affect their relationship with each other (58).

To test if the independent variables were cofactors and/or confounders, the association of the independent variable with BMI (age 30) was tested (a in Figure 1). If the association was significant (P<0.05), the independent variable’s association with breakfast consumption (age 14/19) was also tested (b in Figure 1). If that second association was not significant, the independent variable was included as a cofactor. However, if the second association was significant as well, the independent variable was included as a confounder if the inclusion changed the effect of breakfast on BMI (c in Figure 1) by >± 10 %. If the change in effect, however, was <± 10 %, the independent variable was included as a covariate.

![Figure 1: Model demonstrating the testing of independent variables for inclusion in the multiple regression analyses as covariates or confounder.](image)

To test if the independent variables were moderators, the interaction term (e.g. breakfast · physical activity) was tested for significance. If the interaction term was found to be significant, the analyses were stratified on the independent variable (e.g. physical activity).
4 Results

4.1 Sample characteristics and attrition analyses

Of the 924 (78 %) individuals that participated in the NLHB study at baseline (age 13), 55.2 % were males and 44.8 % were females (data not shown). The reports on parental education showed that 14.0 % of the adolescents had parents with primary and lower secondary school, 43.9 % had parents with upper secondary school and 42.1 % had parents with university and college education (data not shown). Descriptive data of meals and anthropometries are included in the respective sections.

Attrition analyses showed that significantly more males than females dropped out in all the three time periods evaluated (Table 1). Also for parental education there were significant differences between participants and dropouts, with more dropouts in the group of lower parental education. The difference was however, only significant between the age of 14 and 19 years.

Table 1: Comparing socio-demographics and selected behaviours among participants and dropout from the NLHB-study for certain age periods

<table>
<thead>
<tr>
<th>Variable</th>
<th>14-19 years</th>
<th>19-30 years</th>
<th>14-30 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Participants (N= 557)</td>
<td>Drop-outs at age 19 (N=333)</td>
<td>Participants (N=374)</td>
</tr>
<tr>
<td>Gender (% girls)</td>
<td>51.9</td>
<td>33.3***</td>
<td>56.1</td>
</tr>
<tr>
<td>Parental education (% lower education)</td>
<td>51.2</td>
<td>70.6***</td>
<td>51.8</td>
</tr>
<tr>
<td>Breakfast (% daily)</td>
<td>78.5</td>
<td>74</td>
<td>70.0</td>
</tr>
<tr>
<td>Lunch (% daily)</td>
<td>73.9</td>
<td>70.2</td>
<td>54.7</td>
</tr>
<tr>
<td>Dinner (% daily)</td>
<td>82.2</td>
<td>83.3</td>
<td>68.9</td>
</tr>
<tr>
<td>Supper (% daily)</td>
<td>59.9</td>
<td>66.7</td>
<td>36.5</td>
</tr>
<tr>
<td>Physical activity (% &lt; 2-3 h/week)</td>
<td>25.0</td>
<td>28.0</td>
<td>56.2</td>
</tr>
<tr>
<td>BMI (% BMI ≥25)</td>
<td>3.8</td>
<td>6.8</td>
<td>11.3</td>
</tr>
</tbody>
</table>

* P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001 for difference between participants and drop-outs.

a Lower parental education includes those with primary school, lower secondary school or upper secondary school.

b BMI (body mass index, kg/m²)-calculations were based on self-reported weight and height.

For behaviours and overweight, the only significant difference between participants and dropout rate was found in prevalence of supper consumption between age 14 and 30 years, with a larger proportion of dropouts being daily consumers of supper.
4.2 Meal frequencies and daily consumers—changes by age and gender differences

4.2.1 Breakfast

Frequency of breakfast consumption mainly showed a decrease by age for both genders, before it increased again from the age of 21 years for the females, whereas the males only had a minor non-significant increase from the age of 23 years onwards (Table 2). The changes were mostly quite small, except the males decreased their breakfast consumption by about 1 time/week from the age 13 years to the age 23 years, and remained there at age 30. There were significant gender differences in breakfast consumption at ages 14, 15, 23 and 30. At ages 14 and 15 the boys ate breakfast more often than the girls, whereas at ages 23 and 30 it was opposite. The differences were small, except for at age 30 when the difference was more than once per week (females 6.2 vs. males 5.0 times/week).

The gender differences in the proportion of daily consumers of breakfast showed a similar pattern to the frequency data (Table 2), with the largest gender difference at age 30 when only 57.0 % of the males versus 76.5 % of the females reported to be daily breakfast consumers. The changes by age were more pronounced in the proportion of daily consumers compared to the frequency data. The largest difference for the males was between 75.3 % at age 13 and, 50.2 % at age 23, whereas for the females it was between 74.4 % age 13 and, 57.9 % at age 21. The first main decreases in both genders were found from age 15 to 18; 11.9 percentage points’ decrease for the males and 8.5 percentage points’ decrease for the females. The second main decreases, started at age 19 years for both genders, but lasted longer for the males compared to the females.
Table 2: Prevalence of daily consumers (%) and mean frequency of consumption (times/week ± 95% confidence interval (CI)) of the different meals.

<table>
<thead>
<tr>
<th>Meals and age (years)</th>
<th>Males</th>
<th></th>
<th>Females</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Daily Consumers</td>
<td>Times/week</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percent</td>
<td>Mean (95% CI)</td>
<td></td>
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<tr>
<td>Breakfast</td>
<td></td>
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<tr>
<td>13</td>
<td>369</td>
<td>75.3</td>
<td>6.0 (5.8-6.2)</td>
<td>328</td>
</tr>
<tr>
<td>14</td>
<td>449</td>
<td>80.4</td>
<td>6.2 (6.1-6.4)</td>
<td>372</td>
</tr>
<tr>
<td>15</td>
<td>473</td>
<td>80.3</td>
<td>6.1 (6.0-6.3)</td>
<td>384</td>
</tr>
<tr>
<td>18</td>
<td>323</td>
<td>68.4</td>
<td>5.7 (5.4-5.9)</td>
<td>332</td>
</tr>
<tr>
<td>19</td>
<td>269</td>
<td>67.3</td>
<td>5.7 (5.4-6.0)</td>
<td>293</td>
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<tr>
<td>21</td>
<td>239</td>
<td>58.6</td>
<td>5.3 (5.0-5.6)</td>
<td>278</td>
</tr>
<tr>
<td>23</td>
<td>265</td>
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<td>4.9 (4.6-5.2)</td>
<td>275</td>
</tr>
<tr>
<td>30</td>
<td>221</td>
<td>57.0</td>
<td>5.0 (4.7-5.4)</td>
<td>243</td>
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<tr>
<td>Lunch</td>
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<td>369</td>
<td>82.9</td>
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<td>471</td>
<td>76.0</td>
<td>6.3 (6.1-6.4)</td>
<td>382</td>
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<td>323</td>
<td>65.6</td>
<td>6.0 (5.8-6.2)</td>
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<td>23</td>
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<td>50.0</td>
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<td>221</td>
<td>64.7</td>
<td>5.9 (5.7-6.1)</td>
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<td>35.7</td>
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<td>243</td>
</tr>
</tbody>
</table>

* P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001 for difference between males and females.
4.2.2 Lunch

Also for lunch both genders mainly reported decreasing frequency of consumption with age, but with an increase again between ages 21 and 30 for the males, and between ages 19 and 30 for the females (Table 2). The gender patterns of change by age were more similar for the frequencies of lunch consumption than for breakfast consumption. At baseline frequencies of lunch were 6.5 and 6.3 times/week for males and females, respectively. At age 30 the corresponding figures were 5.9 and 6.1 times/week, respectively. The females were slightly lower in lunch consumption at all time points compared to the males, except at age 30. Significant gender differences were evident at ages 13, 14, 15 and 19. The differences were, however, small and was at the most 0.6 times/week (age 14 and 15).

In general, the gender differences found in the proportion of daily consumers of lunch was the same as for the frequency data (Table 2), but the prevalence of daily consumers showed a more pronounced change by age compared to the frequency data. The largest difference for the males was between 82.9 % at age 13 and, 50.0 % at age 23, whereas, for the females it was between 80.9 % at age 13 and, 48.2 % at age 21. The changes for the males occurred especially from ages 15 to 18, decreasing from 76.0 % to 65.6 %, and again from ages 23 to 30 years, where it increased from 50.0 % to 64.7 %. For the females the major changes occurred from age 13 to 14, when the prevalence decreased from 80.9 % to 68.0 %; from ages 18 to 19, when it decreased from 60.7 % to 49.8 %; and from ages 23 to 30, when it increased from 54.9 % to 69.1 %.

4.2.3 Dinner

Generally both genders reported a high frequency of dinner consumption (between 5.8 and 6.6 times/week) and there were only small changes with age for both genders (Table 2). However, also for dinner there was a slight decrease with age up until ages 21 for males and 19 for females. An increase again in frequency/week for dinner was evident between ages 23 and 30 for the males, and non-significantly from ages 21 to 23 and significantly from ages 23 to 30 for the females. The females reported a lower frequency of dinner consumption at all time point, but it was statistically significant only at ages 14, 15, 18, 19 and 21.

For gender differences, the prevalence of daily consumers of dinner showed a similar pattern to the frequency data (Table 2), but the decrease by age was more pronounced. The largest
difference for the males was between 84.7 % at age 13 and, 63.8 % at age 23, whereas for the females it was between 83.7 % at age 13 and, 55.2 % age 21. The changes in prevalence of daily consumers of dinner for the males occurred especially from ages 19 to 21, decreasing from 76.7 % to 66.4 %, and also from ages 23 to 30, when it increased from 63.8 % to 80.1 %. For the females the major changes occurred from ages 15 to 18, when it decreased from 73.4 % to 60.5 %, and also from ages 23 to 30, when it increased from 58.2 % to 76.1 %.

4.2.4 Supper

Both genders mainly reported initial decreasing frequency of supper consumption with age (Table 2), and then an increase again in frequency between ages 23 and 30, ending at a non significant difference of 4.3 and 4.1 times/week for males and females, respectively. This was the meal that showed the largest change by age for both genders. The males decreased their frequency of consumption from 6.1 times/week at age 13 to 4.1 times/week at age 23, which was their lowest frequency, whereas females decreased their frequency of consumption from 5.2 times/week at age 13 to a low of 3.2 times/week at age 23. This was also the meal that showed the greatest gender differences, and gender differences were significant at all ages except at age 30. The males generally reported to consume supper about one time more/week compared to the females. However, at ages 15 and 18, the differences were even larger, being nearly two times/week at age 18.

Gender differences and change by age in the prevalence of daily consumers of supper showed the same pattern as the frequency data (Table 2). The proportion of daily consumers of supper was quite low for the females at several of the time points, with 54.6 at its highest at age 13 and 19.3 % at its lowest at ages 21 and 23. For the males the proportion of daily consumers decreased from 72.1 % at age 13 to a low of 30.9 % at age 23. The major changes in prevalence of daily consumers of supper for males occurred between ages 15 and 18, decreasing from 69.6 % to 52.3 % and between ages 19 and 21, decreasing from 45.7 % to 34.0 %. For the females the main changes occurred between ages 14 and 18, decreasing from 48.1 % to 22.3 %; and also from ages 19 to 21 decreasing from 29.6 % to 19.3 %.
4.3 Tracking of breakfast

The lines in Figure 2a do not cross at any time point indicating that among males, consumption of breakfast exhibit rank stability between the three groups formed by their frequency of consumption at age 14 years. Also, those who at age 14 years reported to eat breakfast daily had significantly different (P<0.05) frequency of breakfast consumption at all subsequent time points of measure compared to those who at age 14 years reported to eat breakfast ≤ 1-3 times/week (Figure 2a).

![Figure 2a](image_url)

**Figure 2a:** Mean consumption frequencies of breakfast (times/week ±95%CI) among males at ages 15-30 in groups reporting to consume breakfast daily, 4-6 times/week, or 1-3 times/week or less at age 14 years.

As Figure 2a shows, the males who ate breakfast daily at age 14 years decreased in breakfast consumption all the way up to age of 23 years, before they seemed to become stable on a level consuming breakfast 5-6 times/week. This pattern is quite similar to the pattern described for the male cohort as a whole in Table 2. However the pattern was somewhat different for the two other, groups. Those males who ate breakfast 4-6 times/week at age 14 years had their most substantial decrease up until age 18, after that they had a slight increase towards age 19, before becoming quite stable around 4 times/week throughout the study. Those males who ate breakfast most seldom at age 14 (≤ 1-3 times/week), stayed quite stable on a level of 2-3 times/week before the age of 21 years. From the age of 21 to 23 years they
had a little decrease in breakfast consumption, before increasing substantially from the age of 23 to 30 years, ending on a level of almost 4 times/week at age 30 years.

In terms of relative stability, the lines in Figure 2b drawn through the group means do not cross at any time point, but one. Similar to the males, those females who at age 14 reported to eat breakfast daily had significantly higher frequency of breakfast consumption at all subsequent time points of measure compared to those who at age 14 reported to eat breakfast \( \leq 1\text{-}3 \) times/week. As the two groups kept their relative ranking, the results suggest tracking of breakfast consumption also for the females.

![Figure 2b](image)

**Figure 2b**: Mean consumption frequencies of breakfast (times/week ±95%CI) among females at ages 15-30 in groups reporting to consume breakfast daily, 4-6 times/week, or 1-3 times/week or less at age 14.

The females who reported to eat breakfast daily at age 14 decreased their breakfast frequency slightly towards the age of 23 (although not as much as the males), before increasing their breakfast consumption again towards the age of 30 (Figure 2b). This pattern is quite similar to the pattern described for the female cohort as a whole in Table 2. Again, the pattern was somewhat different for the two other, groups. Those females who ate breakfast 4-6 times/week at age 14 had a decrease in breakfast consumption up until age 18, after that they had an increase towards the age of 23, before staying quite stable form the age of 23 to 30. Those females who reported to eat breakfast most rarely at age 14 had an increase in breakfast consumption.
consumption towards the age of 19, before decreasing again towards the age of 21. After that they increased all the way up to the age of 30.

### 4.4 Weight and height

Table 3a and 3b show that both males and females increased their BMI with age. The males increased from a mean BMI of 22.1 kg/m² at age 18 years to a mean BMI of 25.5 kg/m² at age 30 years (Table 3a), whereas the females increased from a mean of BMI 21.3 kg/m² at age 18 years to a mean BMI of 24.0 kg/m² at age 30 years (Table 3b). Comparison of mean BMI for pregnant women and non-pregnant women at ages 23 and 30 (which was the only time points this measure was asked for), showed no significant differences (P = 0.83 and P=0.50, respectively – results are not shown). Gender differences in BMI were significant at all time points of measure from age 18 to 30, the females being lower in mean BMI compared to the males – as indicated by comparing the 95 % CIs in Table 3a and 3b.

Table 3a: Height a, weight, BMI and percentage of overweight at the different ages among males in the NLHB-study.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²) b</th>
<th>% Overweight c, d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>SD</td>
<td>N</td>
</tr>
<tr>
<td>13</td>
<td>420</td>
<td>160.9</td>
<td>9.0</td>
<td>466</td>
</tr>
<tr>
<td>14</td>
<td>427</td>
<td>168.8</td>
<td>9.0</td>
<td>439</td>
</tr>
<tr>
<td>15</td>
<td>454</td>
<td>174.2</td>
<td>7.8</td>
<td>461</td>
</tr>
<tr>
<td>18</td>
<td>310</td>
<td>181.3</td>
<td>6.4</td>
<td>308</td>
</tr>
<tr>
<td>19</td>
<td>266</td>
<td>181.1</td>
<td>6.6</td>
<td>267</td>
</tr>
<tr>
<td>21</td>
<td>237</td>
<td>181.5</td>
<td>6.4</td>
<td>233</td>
</tr>
<tr>
<td>23</td>
<td>260</td>
<td>181.3</td>
<td>7.0</td>
<td>258</td>
</tr>
<tr>
<td>30</td>
<td>213</td>
<td>181.6</td>
<td>6.5</td>
<td>217</td>
</tr>
</tbody>
</table>

a Heights and weights were self-reported, and BMI (body mass index, kg/m²)-calculations were based on these reports.
b BMI values were only calculated for the subjects from the age of 18, as the use of BMI as a measure of body weight in children and adolescents is not directly comparable to the use of BMI in adults.
c The International Obesity Task Force age and gender-specific cut-off values (40) were used to determine overweight at age 14. For ages > 18 years, normal weight was defined as BMI < 25 and overweight as BMI ≥ 25 (11).
d The overweight prevalence includes obese subjects.
### Table 3b: Height, weight, BMI and percentage of overweight at the different ages among females in the NLHB-study.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>Overweight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N Mean SD</td>
<td>N Mean SD</td>
<td>N Mean (95% CI)</td>
<td>% (95% CI)</td>
</tr>
<tr>
<td>13</td>
<td>356 161.6  6.5</td>
<td>355 47.6  7.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>333 164.8  6.2</td>
<td>327 51.9  7.1</td>
<td>320 21.3 (21.0-21.6)</td>
<td>3.8 (1.7-5.8)</td>
</tr>
<tr>
<td>15</td>
<td>375 166.5  5.6</td>
<td>365 55.4  7.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>321 168.2  5.9</td>
<td>316 60.3  8.1</td>
<td>310 21.3 (21.0-21.6)</td>
<td>7.1 (4.2-10.0)</td>
</tr>
<tr>
<td>19</td>
<td>290 168.3  5.9</td>
<td>284 61.4  8.4</td>
<td>283 21.7 (21.4-22.0)</td>
<td>11.0 (7.3-14.6)</td>
</tr>
<tr>
<td>21</td>
<td>276 168.4  5.9</td>
<td>271 62.6  8.5</td>
<td>269 22.1 (21.8-22.5)</td>
<td>15.2 (10.9-19.6)</td>
</tr>
<tr>
<td>23</td>
<td>270 168.6  6.0</td>
<td>265 64.1  10.3</td>
<td>262 22.5 (22.1-23.0)</td>
<td>18.3 (13.6-23.0)</td>
</tr>
<tr>
<td>30</td>
<td>231 168.4  6.7</td>
<td>236 67.7  10.9</td>
<td>231 24.0 (23.5-24.5)</td>
<td>33.3 (27.2-39.5)</td>
</tr>
</tbody>
</table>

* a Heights and weights were self-reported, and BMI (body mass index, kg/m²)-calculations were based on these reports.

* b BMI values were only calculated for the subjects from the age of 18, as the use of BMI as a measure of body weight in children and adolescents is not directly comparable to the use of BMI in adults.

* c The International Obesity Task Force age and gender-specific cut-off values (40) were used to determine overweight at age 14. For ages > 18 years, normal weight was defined as BMI < 25 and overweight as BMI ≥ 25 (11).

* d The overweight prevalence includes obese subjects.

Tables 3a and 3b also show the proportions of overweight, for males and females, respectively. From the 95 % CIs it can be seen that gender differences in overweight prevalence were only present at ages 23 and 30 years. At age 14 years, only 5.7 % of the males and 3.8 % of the females were overweight. The prevalence of overweight increased by age in both genders. At age 30, 50.7 % of the males and 33.3 % of the females were found to be overweight. Between age 21 and 23 years the males had a large increase in the proportion being overweight; from 17.7 % to 30.1 %. In the same period the females had a relatively modest increase from 15.2 % to 18.3 %. From the age of 23 to 30 years, both genders showed a substantial increase in the proportions being overweight.

### 4.5 Breakfast consumption and BMI

Cross-sectionally, there were no differences in mean BMI between daily and non-daily consumers of breakfast, neither in males nor females at any of the time points from age 19 to 30, neither were there any clear but non-significant tendencies of patterns (Table 4a and 4b).
Table 4a: Male mean BMI at ages 19, 21, 23 and 30 in groups reporting to be daily consumers and non-daily consumers of breakfast at those ages, respectively (cross sectional):

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>19</th>
<th>21</th>
<th>23</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast consumption</td>
<td>N</td>
<td>Mean BMI (95% CI)</td>
<td>P-value</td>
<td>N</td>
</tr>
<tr>
<td>Daily consumer</td>
<td>176</td>
<td>22.4 (22.1, 22.8)</td>
<td>0.31</td>
<td>135</td>
</tr>
<tr>
<td>Non-daily consumer</td>
<td>83</td>
<td>22.8 (22.2, 23.4)</td>
<td></td>
<td>95</td>
</tr>
</tbody>
</table>

a All BMI (body mass index, m/kg²)-calculations were based on self-reported weight and height.

Table 4b: Female mean BMI at ages 19, 21, 23 and 30 in groups reporting to be daily consumers and non-daily consumers of breakfast at those ages, respectively (cross sectional):

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>19</th>
<th>21</th>
<th>23</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast consumption</td>
<td>N</td>
<td>Mean BMI (95% CI)</td>
<td>P-value</td>
<td>N</td>
</tr>
<tr>
<td>Daily consumer</td>
<td>193</td>
<td>21.6 (21.3, 22.0)</td>
<td>0.99</td>
<td>152</td>
</tr>
<tr>
<td>Non-daily consumer</td>
<td>87</td>
<td>21.6 (21.1, 22.2)</td>
<td></td>
<td>114</td>
</tr>
</tbody>
</table>

a All BMI (body mass index, m/kg²)-calculations were based on self-reported weight and height.
4.5.1 Breakfast consumption and longitudinal mean BMI

**Males**

There was a tendency that males who were non-daily consumers of breakfast at age 14 had higher mean BMI at the subsequent time points, than males who consumed breakfast daily, although a significant difference in BMI was only found at age 30 (P=0.004) (Table 5a). When using breakfast consumption at age 19 years as baseline, the pattern was the same, and also here significant difference was only detected at age 30 years (P = 0.002) (Table 5a).

**Males stratified on weight status at the respective baseline time points**

For the normal weight males there were no significant differences in mean BMI at any of the subsequent time points between groups who reported to be daily consumers and non-daily consumers of breakfast at age 14 (Table 5b). However, the tendency for all the subsequent time points was that the group of non-daily consumers had higher mean BMI than daily consumers. When using the reports on breakfast consumption from age 19 as baseline, the tendency was the same, and with a significant difference in mean BMI at age 30 (P = 0.03) (Table 5b).

At age 14 years, there were too few overweight males to study BMI differences at the subsequent time points of measure based on their consumption of breakfast at age 14 years.

There were no significant differences in mean BMI between the male overweight groups who reported to be daily consumers or non-daily consumers of breakfast at age 19 (Table 5b). Although not significant, the non-daily consumers had a higher mean BMI compared to the daily consumers both at ages 21 and 30 years (at age 30 years the difference was borderline significant).
Table 5a: Mean BMI \(^a\) at ages 19, 21, 23 and 30 of males reporting to be daily or non-daily consumers of breakfast at ages 14 and 19, respectively.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Baseline</th>
<th>19</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>21</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>23</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>30</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Daily consumer</td>
<td>192</td>
<td>22.4</td>
<td>(22.1, 22.8)</td>
<td>0.12</td>
<td>173</td>
<td>23.4</td>
<td>(22.7, 23.5)</td>
<td>0.51</td>
<td>191</td>
<td>23.7</td>
<td>(23.3, 24.1)</td>
<td>0.33</td>
<td>153</td>
<td>25.2</td>
<td>(24.8, 25.7)</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>46</td>
<td>23.1</td>
<td>(22.2, 23.9)</td>
<td></td>
<td>40</td>
<td>23.4</td>
<td>(22.6, 24.2)</td>
<td></td>
<td>43</td>
<td>24.1</td>
<td>(23.2, 25.1)</td>
<td></td>
<td>33</td>
<td>26.9</td>
<td>(25.7, 28.2)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Daily consumer</td>
<td>135</td>
<td>23.0</td>
<td>(22.5, 23.4)</td>
<td>0.08</td>
<td>137</td>
<td>23.7</td>
<td>(23.2, 24.2)</td>
<td>0.45</td>
<td>112</td>
<td>24.9</td>
<td>(24.3, 25.4)</td>
<td>0.002*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>59</td>
<td>23.7</td>
<td>(23.0, 24.3)</td>
<td></td>
<td>58</td>
<td>24.0</td>
<td>(23.3, 24.8)</td>
<td></td>
<td>45</td>
<td>26.7</td>
<td>(25.7, 27.7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant difference between daily and non-daily consumers of breakfast (P < 0.05).

\(^a\) All BMI (body mass index, m/kg\(^2\))-calculations were based on self-reported weight and height.

Table 5b: Comparison of mean BMI \(^a\) at ages 19, 21, 23 and 30 years between groups of males reporting to be daily or non-daily consumers of breakfast at baseline. The baseline ages for the analyses were 14 or 19 years. The comparisons were done separate for cohorts of subjects reporting to be normal weight and overweight at baseline.

<table>
<thead>
<tr>
<th>Age (years), weight category (^b)</th>
<th>Baseline</th>
<th>19</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>21</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>23</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>30</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>14, normal weight (^c)</td>
<td>Daily consumer</td>
<td>171</td>
<td>22.3</td>
<td>(22.0, 22.6)</td>
<td>0.10</td>
<td>158</td>
<td>23.1</td>
<td>(22.7, 23.4)</td>
<td>0.72</td>
<td>172</td>
<td>23.6</td>
<td>(23.2, 24.0)</td>
<td>0.92</td>
<td>138</td>
<td>25.0</td>
<td>(24.6, 25.5)</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>34</td>
<td>23.0</td>
<td>(22.2, 23.9)</td>
<td></td>
<td>27</td>
<td>23.3</td>
<td>(22.2, 24.3)</td>
<td></td>
<td>31</td>
<td>23.7</td>
<td>(22.5, 24.8)</td>
<td></td>
<td>26</td>
<td>26.7</td>
<td>(25.2, 28.2)</td>
<td></td>
</tr>
<tr>
<td>19, normal weight</td>
<td>Daily consumer</td>
<td>119</td>
<td>22.6</td>
<td>(22.2, 23.0)</td>
<td>0.13</td>
<td>121</td>
<td>23.2</td>
<td>(22.7, 23.6)</td>
<td>0.52</td>
<td>95</td>
<td>24.5</td>
<td>(24.0, 25.0)</td>
<td>0.03 *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>48</td>
<td>23.2</td>
<td>(22.5, 23.8)</td>
<td></td>
<td>49</td>
<td>23.4</td>
<td>(22.7, 24.1)</td>
<td></td>
<td>38</td>
<td>26.0</td>
<td>(25.1, 26.9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19, overweight</td>
<td>Daily consumer</td>
<td>13</td>
<td>26.4</td>
<td>(24.6, 28.2)</td>
<td>0.56</td>
<td>15</td>
<td>28.0</td>
<td>(26.5, 29.5)</td>
<td>0.68</td>
<td>13</td>
<td>28.2</td>
<td>(25.9, 30.5)</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>8</td>
<td>27.1</td>
<td>(25.5, 28.8)</td>
<td></td>
<td>7</td>
<td>27.5</td>
<td>(26.4, 28.6)</td>
<td></td>
<td>6</td>
<td>31.5</td>
<td>(28.8, 34.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant difference between daily and non-daily consumers of breakfast (P < 0.05).

\(^a\) All BMI (body mass index, m/kg\(^2\))-calculations were based on self-reported weight and height.

\(^b\) The International Obesity Task Force age and gender-specific cut-off values (40) were used to determine overweight at age 14. For ages > 18 years, normal weight was defined as BMI < 25 and overweight as BMI ≥ 25 (11).

\(^c\) There were too few overweight males at age 14 to compare the daily consumers and the non-daily consumers in this group at subsequent time points of measure.
**Females**

For the females there were significant differences in mean BMI at ages 19, 21 and 23 years (P=0.01, P=0.01, P=0.05, respectively), between those who reported to be daily and non-daily consumers of breakfast at age 14 years (Table 6a). The direction of the differences was that non-daily consumers had a higher mean BMI compared to the daily consumers. Also, at 30 years the difference in mean BMI between daily and non-daily consumers of breakfast at age 14 years, bordered significance (P=0.07). When using breakfast consumption at age 19 as baseline, there were no significant differences in mean BMI at any of the subsequent time points (Table 6a), nor was there any pattern.

**Females stratified on weight status at the respective baseline time points**

For the normal weight females there were significant differences in mean BMI at ages 19 (P = 0.01), 21 (P = 0.01) and 23 years (P = 0.02) between groups who reported to be daily or non-daily consumers of breakfast at age 14 years (Table 6b). The non-daily consumers of breakfast had a mean BMI that was about one BMI unit higher at ages 19, 21, 23 and 30 years compared to the daily consumers (although not significant at age 30 years).

Between normal weight female daily and non-daily consumers of breakfast at age 19 years, there were no significant differences in mean BMI at any subsequent time points (Table 6b). However, the tendency for all the time points was that the non-daily consumers of breakfast at age 19 years had a lower mean BMI than the daily consumers. This tendency is the opposite of the pattern that was seen in all the other analyses, suggesting that skipping breakfast once in a while might not be detrimental on weight development if you are a 19-year old normal weight female.

As for the males, there were too few females who were overweight at age 14 years to say anything about BMI differences at the subsequent time points of measure based on their consumption of breakfast at age 14 years.
Table 6a: Mean BMI \(^a\) at ages 19, 21, 23 and 30 of females reporting to be daily or non-daily consumers of breakfast at ages 14 and 19, respectively.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Breakfast consumption</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Daily consumer</td>
<td>199</td>
<td>21.4 (21.1, 21.8)</td>
<td>0.01 *</td>
<td>186</td>
<td>21.8 (21.4, 22.3)</td>
<td>0.01 *</td>
<td>185</td>
<td>22.2 (21.7, 22.7)</td>
<td>0.05 *</td>
<td>159</td>
<td>23.6 (23.0, 24.3)</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>64</td>
<td>22.4 (21.6, 23.2)</td>
<td></td>
<td>60</td>
<td>22.9 (22.1, 23.8)</td>
<td></td>
<td>59</td>
<td>23.2 (22.3, 24.2)</td>
<td></td>
<td>53</td>
<td>24.9 (23.6, 26.1)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Daily consumer</td>
<td>164</td>
<td>22.1 (21.7, 22.6)</td>
<td>1.00</td>
<td>155</td>
<td>22.6 (22.0, 23.1)</td>
<td>0.97</td>
<td>136</td>
<td>23.9 (23.3, 24.6)</td>
<td>0.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>75</td>
<td>22.1 (21.4, 22.9)</td>
<td></td>
<td>68</td>
<td>22.6 (21.7, 23.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>23.9 (22.7, 25.1)</td>
<td></td>
</tr>
</tbody>
</table>

* Significant difference between daily and non-daily consumers of breakfast (P < 0.05).

\(^a\) All BMI (body mass index, m/kg\(^2\))-calculations were based on self-reported weight and height.

Table 6b: Comparison of mean BMI \(^a\) at ages 19, 21 and 30 years between groups of females reporting to be daily or non-daily consumers of breakfast at baseline. The baseline ages for the analyses were 14 or 19 years. The comparisons were done separate for cohorts of subjects reporting to be normal weight and overweight at baseline.

<table>
<thead>
<tr>
<th>Age (years), weight category (^b)</th>
<th>Breakfast consumption</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
<th>N</th>
<th>Mean BMI (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>14, normal weight</td>
<td>Daily consumer</td>
<td>162</td>
<td>21.2 (20.8, 21.6)</td>
<td>0.01 *</td>
<td>151</td>
<td>21.6 (21.2, 22.0)</td>
<td>0.01 *</td>
<td>152</td>
<td>21.9 (21.5, 22.4)</td>
<td>0.02 *</td>
<td>128</td>
<td>23.4 (22.7, 24.1)</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>54</td>
<td>22.3 (21.4, 23.1)</td>
<td></td>
<td>50</td>
<td>22.8 (21.9, 23.7)</td>
<td></td>
<td>50</td>
<td>23.2 (22.1, 24.3)</td>
<td></td>
<td>43</td>
<td>24.5 (25.2, 25.8)</td>
<td></td>
</tr>
<tr>
<td>19, normal weight</td>
<td>Daily consumer</td>
<td>140</td>
<td>21.4 (21.1, 21.8)</td>
<td>0.71</td>
<td>133</td>
<td>21.9 (21.4, 22.3)</td>
<td>0.51</td>
<td>118</td>
<td>23.2 (22.6, 23.7)</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>65</td>
<td>21.3 (20.8, 21.8)</td>
<td></td>
<td>59</td>
<td>21.6 (21.0, 22.2)</td>
<td></td>
<td>52</td>
<td>22.9 (22.0, 23.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19, overweight</td>
<td>Daily consumer</td>
<td>19</td>
<td>27.0 (25.8, 28.2)</td>
<td>0.14</td>
<td>17</td>
<td>27.6 (25.8, 29.4)</td>
<td>0.34</td>
<td>14</td>
<td>29.6 (26.4, 32.9)</td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-daily consumer</td>
<td>7</td>
<td>28.9 (25.6, 32.2)</td>
<td></td>
<td>7</td>
<td>29.0 (26.4, 31.6)</td>
<td></td>
<td>6</td>
<td>33.1 (28.9, 37.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant difference between daily and non-daily consumers of breakfast (P < 0.05).

\(^a\) All BMI (body mass index, m/kg\(^2\))-calculations were based on self-reported weight and height.

\(^b\) The International Obesity Task Force age and gender-specific cut-off values (40) were used to determine overweight at age 14. For ages > 18 years, normal weight was defined as BMI < 25 and overweight as BMI ≥ 25 (11).

\(^c\) There were too few overweight males at age 14 to compare the daily consumers and the non-daily consumers in this group at subsequent time points of measure.
Between overweight female daily and non-daily consumers of breakfast at age 19 years, there were no significant differences in mean BMI at any subsequent time points (Table 6b). However, the tendency for all the time points was that the females who reported to be non-daily consumers of breakfast at age 19 had higher mean BMI than the females who reported to be daily consumers.

From the results in Table 5a and 6a it seems daily breakfast consumption at age 14 was especially associated with lower BMI later in adolescence and young adulthood for the females. The same pattern was observed for the males, but only one time point of measure reached statistical significance. When applying daily breakfast consumption at age 19 as baseline (Table 5a and 6a), the pattern showed lower BMI later in young adulthood for the males, but not for the females. From this it seems as if the breakfast consumption at age 14 was more important for the females than the males in predicting future BMI, whereas for breakfast consumption at age 19 it was the opposite.
4.6 Multiple regression analyses: Breakfast consumption and BMI at age 30

The variables dieting, gender, parental education and physical activity were tested for inclusion in the multivariable models as possible covariates, confounders or mediators. Table 7 presents the results from these testings. Breakfast is included in all the models, since the main interest was the relationship between breakfast consumption and BMI-development. As physical activity was shown to be a moderator of the relationship between breakfast and BMI in both the “Age 14-model” and the “Age 19-model”, the analyses was performed separately for those with low and high physical activity (PA) levels. This gave rise to four multivariate models: “Age 14-model” for low PA, “Age 14-model” for high PA, “Age 19-model” for low PA, and “Age 19-model” for high PA.

Table 7: Results from the testing of variables for inclusion in the multivariable models together with breakfast consumption at ages 14 or 19 as independent variable and BMI a at age 30 as dependent variable.

<table>
<thead>
<tr>
<th>Dieting b</th>
<th>Gender</th>
<th>Parental education c</th>
<th>Physical activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Age 14- model”</td>
<td>-</td>
<td>confounder</td>
<td>confounder</td>
</tr>
<tr>
<td>“Age 19-model”</td>
<td>-</td>
<td>covariate</td>
<td>confounder</td>
</tr>
</tbody>
</table>

a BMI (Body mass index, kg/m²)-calculations were based on self-reported weight and height.
b Dieting was tested to be neither covariate, confounder or moderator, and was not included in the final models.
c Based on combined reports from parents and adolescents on the parents education.
4.6.1 Multivariable models with independent variables from the adolescents reports at age 14

“Age 14-model” for low PA

Simple regression analysis showed a significantly lower BMI at age 30 with increasing breakfast frequency at age 14 (P < 0.001) among those with low physical activity (Table 8). BMI at age 14 was positively associated with BMI at age 30 in the simple regression analysis (P < 0.001), but gender and parental education showed no significant association (Table 8).

Breakfast consumption remained a significant predictor (P = 0.001) when adjusting for gender and parental education (Table 8). The results suggest that one unit increase in breakfast consumption at age 14, would give a decrease in the mean BMI at age 30 by 0.67 BMI-units.

Finally, BMI at age 14 was highly significant (P < 0.001) in the multivariate model, but breakfast remained significant (P < 0.001). The multivariate model unadjusted for BMI at age 14 explained 18.6 % of the variation in BMI at age 30 (Table 8), while the model adjusted for BMI at age 14 explained 38.7 % of the variation in BMI at age 30.
Table 8: Multiple regression model of BMI at age 30 years and breakfast at age 14 years for those with low levels (<2-3 hours/week) of physical activity at age 14 years. Both crude and adjusted effects are presented.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariable models (N=87)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Multivariate model without BMI at age 14 as independent variable (N=83)</th>
<th>Multivariate model with BMI at age 14 as independent variable (N=80)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted effect</td>
<td>95% CI</td>
<td>P-value</td>
</tr>
<tr>
<td>Breakfast consumption (age 14)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.67</td>
<td>(-1.04, -0.31)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-1.30</td>
<td>(-2.91, -0.32)</td>
<td>0.115</td>
</tr>
<tr>
<td>Parental education&lt;sup&gt;e&lt;/sup&gt;</td>
<td>-0.49</td>
<td>(-2.26, 1.27)</td>
<td>0.580</td>
</tr>
<tr>
<td>BMI (age 14)</td>
<td>0.58</td>
<td>(0.30, 0.86)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note: Dependent variable is BMI (body mass index, kg/m²) at age 30. All beta-values are unstandardized. The effects sizes in the multivariate models are adjusted for all the other variables in the model.

- All BMI calculations are based on self-reported weight and height.
- The number of subjects in the univariate models varies between 87 and 92.
- Continuous: Times/week.
- Males = 1, females = 2.
- Dichotomized: Low/medium = 1, and high parental education = 2 (based on combined parent and adolescents’ report of parents education).
“Age 14-model” for high PA

Simple regression analyses on the group with high physical activity at age 14 showed that parental education and gender were negatively associated with mean BMI at age 30 (P < 0.001 and P = 0.001, respectively) (Table 9). One unit increase in parental education seemed to lower mean BMI at age 30 by 1.72 units. Unadjusted analyses indicated that breakfast consumption at age 14 was not of importance for BMI at age 30 for the high physical activity group (Table 9). The unadjusted effect was -0.18, suggesting only 0.18 BMI-units lower BMI at age 30, given one unit increase in breakfast consumption at age 14, though not significant (P = 0.159).

Breakfast consumption remained a non significant predictor (P = 0.244) when adjusting for gender and parental education (Table 9), whereas gender and parental education remained significant also in the adjusted model (P < 0.001, and P = 0.001, respectively). The effect size decreased a little bit for parental education in the adjusted analyses, but the direction was still the same, indicating lower BMI at age 30 with higher parental education.

Finally, BMI at age 14 was highly significant (P < 0.001) when included in the multivariate model (Table 9). Breakfast remained not significant (P = 0.845), whereas gender and parental education were still significant (P < 0.001 and P = 0.006, respectively). The inclusion of BMI at age 14 in the model did influence the effect size of gender and parental education, as the effect size for gender increased and the effect size for parental education decreased. The multivariate model unadjusted for BMI at age 14 explained 10.2 % of the variation in BMI at age 30 (Table 9), whereas the model adjusted for BMI at age 14 explained 30.3 % of the variation in BMI at age 30.
Table 9: Multiple regression model of BMI \(^a\) at age 30 years and breakfast at age 14 years for those with low levels (≥2-3 hours/week) of physical activity at age 14 years. Both crude and adjusted effects are presented.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariable models (N=261) (^b)</th>
<th>Multivariate model without BMI at age 14 as independent variable (N=250)</th>
<th>Multivariate model with BMI at age 14 as independent variable (N=246)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted effect</td>
<td>Adjusted effect</td>
<td>Adjusted effect</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>P-value</td>
<td>95% CI</td>
</tr>
<tr>
<td>Breakfast consumption (age 14) (^c)</td>
<td>-0.18 (-0.42, 0.07)</td>
<td>0.159</td>
<td>-0.15 (-0.40, 0.10)</td>
</tr>
<tr>
<td>Gender (^d)</td>
<td>-1.46 (-2.31, -0.61)</td>
<td>0.001</td>
<td>-1.64 (-2.52, -0.75)</td>
</tr>
<tr>
<td>Parental education (^e)</td>
<td>-1.72 (-2.58, -0.85)</td>
<td>&lt;0.001</td>
<td>-1.47 (-2.36, -0.58)</td>
</tr>
<tr>
<td>BMI (age 14)</td>
<td>0.82 (0.63, 1.01)</td>
<td>&lt;0.001</td>
<td>0.83 (0.63, 1.03)</td>
</tr>
</tbody>
</table>

\(^a\) All BMI calculations are based on self-reported weight and height.
\(^b\) The number of subjects in the univariate models varies between 261 and 282.
\(^c\) Continuous: Times/week.
\(^d\) Males = 1, females = 2.
\(^e\) Dichotomized: Low/ medium = 1, and high parental education = 2 (based on combined parent and adolescents’ report of parents education).
4.6.2 Multivariable models with independent variables from the adolescents reports at age 19

“Age 19-model” for low PA

Simple regression analysis showed a significantly lower BMI at age 30 with increasing breakfast frequency at age 19 (P = 0.001) among those with low physical activity (Table 10). As expected based on the analyses in the “Age 14-model”, BMI at age 19 was positively associated with BMI at age 30 in the simple regression analysis (P < 0.001). Parental education was also significant in the unadjusted analyses (P = 0.037), whereas gender was not (Table 10).

Breakfast consumption remained a significant predictor (P = 0.001) of BMI at age 30 when adjusting for gender and parental education (Table 10). The results suggested that one unit increase in breakfast consumption at age 19, would give a decrease in BMI at age 30 by 0.47 BMI-units. Parental education did not remain significantly associated with BMI at age 30 in the adjusted analyses (P = 0.059), whereas gender became significant in the adjusted model (P = 0.031).

At last, BMI at age 19 was highly significant (P < 0.001) when included in the multivariate model (Table 10). Breakfast consumption remained significant (P < 0.001), whereas gender was no longer significant. The multivariate model unadjusted for BMI at age 19 explained 13.2 % of the variation in mean BMI at age 30 (Table 10), while adjusting for BMI at age 19 gave a model that explained 57.5 % of the variation in BMI at age 30.
Table 10: Multiple regression model of BMI\(^a\) at age 30 years and breakfast at age 19 years for those with low levels (<2-3 hours/week) of physical activity at age 19 years. Both crude and adjusted effects are presented.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariable models (N=143) (^b)</th>
<th>Multivariate model without BMI at age 19 as independent variable (N=143)</th>
<th>Multivariate model with BMI at age 19 as independent variable (N=135)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted effect 95% CI P-value</td>
<td>Adjusted effect 95% CI P-value</td>
<td>Adjusted effect 95% CI P-value</td>
</tr>
<tr>
<td>Breakfast consumption (age 19)(^c)</td>
<td>-0.49 (-0.77, -0.21) 0.001</td>
<td>-0.47 (-0.74, -0.19) 0.001</td>
<td>-0.39 (-0.59, -0.19) &lt;0.001</td>
</tr>
<tr>
<td>Gender(^d)</td>
<td>-0.92 (-2.24, 0.40) 0.169</td>
<td>-1.40 (-2.67, -0.13) 0.031</td>
<td>-0.51 (-1.44, 0.42) 0.277</td>
</tr>
<tr>
<td>Parental education(^e)</td>
<td>-1.41 (-2.73, -0.08) 0.037</td>
<td>-1.25 (-2.54, -0.05) 0.059</td>
<td>-0.73 (-1.66, 0.21) 0.128</td>
</tr>
<tr>
<td>BMI (age 19)</td>
<td>1.02 (0.86, 1.18) &lt;0.001</td>
<td>0.93 (0.77, 1.10) &lt;0.001</td>
<td></td>
</tr>
<tr>
<td>R(^2)</td>
<td>0.132</td>
<td>0.575</td>
<td></td>
</tr>
</tbody>
</table>

Note: Dependent variable is BMI (body mass index, kg/m\(^2\)) at age 30. All beta-values are unstandardized. The effects sizes in the multivariate models are adjusted for all the other variables in the model.

\(^a\) All BMI calculations are based on self-reported weight and height.

\(^b\) The number of subjects in the univariate models varies between 143 and 152.

\(^c\) Continuous: Times/week.

\(^d\) Males = 1, females = 2.

\(^e\) Dichotomized: Low/ medium = 1, and high parental education = 2 (based on combined parent and adolescents’ report of parents education).
“Age 19-model” for high PA
Simple regression analyses on the group with high physical activity at age 19 showed that breakfast consumption at age 19 was not associated with mean BMI at age 30 for the high physical activity group (P = 0.997) (Table 11). However, parental education and gender were negatively associated with mean BMI at age 30 (P = 0.023) and P = 0.001, respectively). One unit increase in parental education seemed to lower mean BMI at age 30 years by 1.18 units.

In the model adjusting for gender and parental education, breakfast consumption remained not significant (P = 0.821) (Table 11), while gender and parental education remained significant (P = 0.001, and P = 0.054, respectively). The effect size decreased some for parental education in the adjusted analyses, but the direction was still the same, indicating lower BMI at age 30 with higher parental education.

Finally, BMI at age 19 was highly significant (P < 0.001) when included in the multivariate model, while breakfast was still not significant (P = 0.535), and also gender and parental education were no longer significant (P = 0.069 and P = 0.245, respectively). The multivariate model unadjusted for BMI at age 19 explained 8.1 % of the variation in mean BMI at age 30 (Table 11), whereas the adjusted model explained 38.5 % of the variation in BMI at age 30.

Summary for all four models:
When comparing the results (the adjusted models without BMI at baseline included) from the groups of high and low physical activity, both from the “Age 14- model” and the “Age 19-model”, the most striking was the big difference in effect of breakfast consumption. For those with low physical activity, more frequent breakfast consumption seemed to be of importance to keep BMI at age 30 lower, but this was not found in the high physical activity groups. In terms of having a lower mean BMI at age 30, it also seemed as parental education and gender were more important for the high physical activity groups, at least in the “Age 14-model”. The multivariate models for the groups with low physical activity explained more of the variation in BMI at age 30 than the models for the groups with high physical activity, both without and with the BMI at age at an earlier time point included in the models, this suggesting that there may be other factors that play a more important role in explaining the BMI-variation at age 30 in the high physical activity groups.
Table 11: Multiple regression model of BMI at age 30 years and breakfast at age 14 years for those with low levels (>2-3 hours/week) of physical activity at age 19 years. Both crude and adjusted effects are presented.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariable models (N=193)</th>
<th>Multivariate model without BMI at age 19 as independent variable (N=192)</th>
<th>Multivariate model with BMI at age 19 as independent variable (N=189)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted effect 95% CI</td>
<td>Adjusted effect 95% CI P-value</td>
<td>Adjusted effect 95% CI P-value</td>
</tr>
<tr>
<td>Breakfast consumption (age 19)</td>
<td>-0.00 (-0.28, 0.28) 0.997</td>
<td>0.03 (-0.24, -0.31) 0.821</td>
<td>-0.07 (-0.30, -0.16) 0.535</td>
</tr>
<tr>
<td>Gender d</td>
<td>-1.66 (-2.65, -0.67) 0.001</td>
<td>-1.68 (-2.67, -0.69) 0.001</td>
<td>-0.79 (-1.64, -0.06) 0.069</td>
</tr>
<tr>
<td>Parental education e</td>
<td>-1.18 (-2.20, -0.17) 0.023</td>
<td>-0.97 (-1.96, 0.02) 0.054</td>
<td>-0.49 (-1.13, 0.34) 0.245</td>
</tr>
<tr>
<td>BMI (age 19)</td>
<td>0.97 (0.80, 1.13) &lt;0.001</td>
<td>0.90 (0.71, 1.09) &lt;0.001</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.081 0.385</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Dependent variable is BMI (body mass index, kg/m²) at age 30. All beta-values are unstandardized. The effects sizes in the multivariate models are adjusted for all the other variables in the model.

- All BMI calculations are based on self-reported weight and height.
- The number of subjects in the univariate models varies between 193 and 200.
- Continuous: Times/week.
- Males = 1, females = 2.
- Dichotomized: Low/medium = 1, and high parental education = 2 (based on combined parent and adolescents’ report of parents education).
5 Discussion

There were several main findings in this thesis. Firstly, both males and females had an initial decrease in both frequency of consumption and proportion of daily consumers for all meals with age, before increasing in consumption again in young adulthood. Secondly, gender differences were evident at several times point for all the meals; mainly males consumed the meals more frequently than the females. Thirdly, tracking of breakfast consumption was found from the age of 14 up until the age of 30 years, in both males and females. Fourthly, cross-sectionally no differences in mean BMI were found between daily and non-daily consumers of breakfast. Fifthly, daily consumers of breakfast had lower mean BMI in the longitudinal analyses (some significant and some non-significant results), compared to non-daily consumers (with the exception of normal weight females when applying age 19 as baseline). Finally, more frequent breakfast consumption at age 14 or 19 was significantly associated with lower mean BMI at age 30 for those reporting to be low in physical activity at age 14 or 19, this was still significant when adjusting for gender, parental education and baseline BMI. This association was not found in groups of high physical activity, neither when using age 14 or 19 as baseline.

In the following, this section will discuss some methodological issues, before discussing the results and concluding with some implications for practitioners and research.

5.1 Methodological issues

5.1.1 Design

The strength of the present study is its longitudinal approach, with nine measurement points across 17 years, but the time between the two last measurements was rather long and thus the changes in this period is less well reflected. In longitudinal studies the causality criteria of temporality is satisfied, but association observed in non-randomized studies is not similar to a confirmation of an effect by a randomized trial (60) and the results should be interpreted with this in mind. As a prospective cohort study, this study has advantages in terms of being less prone to recall bias compared to retrospective studies, since data are collected of usual behaviour at the time and used in analyses of later collected data. The design of the NLHB study does not allow for the separation of secular trends from possible age trends since the
participants from only one age group was recruited. Another advantage of the study is the wide range of health related topics enquired about, which provide the possibility to adjust for several relevant variables in the analyses. But the wide spectrum of topics enquired about also make the amount and specificity of information for each health behaviour limited.

5.1.2 Participants

As mentioned earlier, the cohort is assumed to be representative of the adolescents of this birth cohort in Hordaland county (46). Only to the extent that the adolescents in Hordaland are representative for the other counties in Norway, may these results be generalized nationally.

As in all longitudinal studies participants were lost to follow up. Attrition analyses showed that for all the time intervals included (14-19, 19-30 and 14-30 years of age) there were more male dropouts than female dropouts. Most analyses in this thesis were separated by gender, therefore the impact of this would mainly be a possible smaller variability in the male group. For the analysis not separated by genders, the gender bias might affect the results in the way that female adolescents in several studies have been shown to exhibit more health conscious behaviours in terms of food choices (57;61) that might affect weight development. But female adolescents have also been shown to skip breakfast and other meals more often than males (22;62-65), and also to participate less in physical activity (65). From this it might be drawn that the weight outcome (i.e. mean BMI) could have been reduced from the true mean by the bad health behaviours that affect body weight that are overrepresented in females, whereas the weight outcome (i.e. mean BMI) could have been increased from the true mean, by the good health behaviours affecting body weight that are overrepresented by females. The possibility of the mean deviating from the true mean in different direction as a result of the more frequent dropout in males, might indicate that the more frequent dropout of males would not affect the results in the analyses on BMI. Also for parental education there were differences in dropout rates, but only between the age of 14 and 19 years. Specifically there were more dropouts in the group of adolescents with parents having lower (or medium) education, compared to in the group of adolescents with parents having higher education. Adolescents with a higher socioeconomic background have been shown to have healthier food choices, more regular breakfast consumption, as well as having a lower prevalence of obesity (66). A more homogenous sample in terms of parental education might therefore indicate less variation in
the health behaviours associated with body weight, and then making it more difficult to detect associations from the period of 14-19 years of age. A little surprisingly the dropouts between age 14 and 30 deviated from the adolescents participating both at age 14 and 30 in daily supper consumption, the proportion of daily consumers of supper being higher in the dropouts compared to the participants. Supper was only part of the early analyses illuminating gender differences in meal frequencies. As dropouts had a higher daily supper consumption, the analyses estimating frequency of supper at later ages might underestimate the supper consumption in the cohort as a whole. This could have consequences if one should want to look into total meal frequency in future projects.

It should be noted that no evaluation of the imbalance in a baseline risk factor alone can reveal the amount of potential confounding, because it depends on the interplay between that imbalance and the relation of the risk factor to the outcome. However, the imbalances in baseline values could at least give us an indication on how to interpret the results.

5.1.3 Quality of measures

Self-report measures are generally associated with some degree of uncertainty about the accuracy of the reportings. This because the questions could be misunderstood, and also, some degree of recall bias could still be present despite the prospective approach in this study. In addition, response bias e.g. social desirability is not uncommon (67). Self-reports are, nevertheless, often chosen over direct measurements because of advantages such as practicality and low costs, as well as being quick and easy to administer, and also being a good method for sampling a large number of individuals. Some issues of the self-reported variables used in this thesis will be addressed in the following.

Self-report of meal frequency

Information about reproducibility is important because poor reproducibility could for example make it difficult to assess whether a difference between the administrations of a questionnaire was because of inaccurate recall or as a result of an actual change in behaviour. Test-retest coefficients varied between (kappa) 0.60 and 0.81 for the daily consumption of the meals breakfast, lunch and dinner, with breakfast having the highest coefficient. For the frequency data on the meals breakfast, lunch and supper the kappa coefficients varied between 0.54 and 0.71, with breakfast having the highest coefficient. While no absolute definitions for the
interpretation of the kappa values are agreed upon, according to the guidelines from Landis and Koch the strength of agreement is good (68) for the daily consumption variables, and moderate to good for the frequency variables.

No validation studies on self-reports of meal frequencies were found in the literature. It might be hard to determine a golden standard for comparison with a meal frequency questionnaire, but possibly a food diary would be helpful for future validation studies of meal frequencies – even though both methods would rely on self-reports.

**Self-reporting of body weight and height, and use of BMI as a measure of body composition**

Self-reported weight and height are used for the BMI-calculations in this thesis. A review of studies in US populations, evaluating adolescent self-report of height and weight, found that height was both overestimated and underestimated, whereas weight and BMI was underestimated, compared to direct measure (69). Furthermore, overweight and female youth underestimated their weight (and thus also BMI calculated from self-report of weight and height), more than normal-weight and male youth, respectively. This could have implications for the mean weight and height calculated for the adolescents under the age of 18 in this study, in terms of a possible underestimation of the mean weight in both males and females, but more so in the females group. Also it implicates an uncertainty about the estimate of mean height, in that the estimate could be both over- and underestimated. The same review (69) points out that because of the bias of underestimation of weight and BMI by weight status, self-reported data underestimated the overweight prevalence. Sensitivity data were provided showing that 25 % to 45 % of those overweight would be missed if self-reported data were used. A greater proportion of the subjects in this thesis might thus have been categorized in the normal weight group at age 14, when they should have been in the overweight group.

Similar findings were reported in a review on adult populations (70), with the exception of a more consistent overestimation of height, compared to what was seen in the adolescents. As mentioned above, this could have implications for the mean heights and mean weights estimated in this thesis, in terms of a possible overestimation of mean height and underestimation of mean weight also at ages 18 years and above, and thus a lower BMI and lower proportion of overweight subjects. In the EPIC-Oxford study, Spencer et al. (71) found that self-reporting of height and weight incorrectly classified about 20 % of both men and
women when using standard categories of BMI. The BMI-variable at age 19 was
dichotomized in several of the analyses in this thesis. The possible under-reporting of weight
and over-reporting of height could have lead to subjects that were on the borderline of being
overweight, were classified as normal weight, when actually they should have been in the
overweight category. However, the proportion of overweight in this thesis is quite high for the
last time points, but still in accordance with other studies in Norway (72;73) which may imply
that the underestimation was not substantial in the adult period.

The concern in analyses where one wants to identify factors associated with overweight and
non-overweight using a dichotomous variable of BMI, is that to the extent that the self-
reported weight and height data misclassify adolescent (or adult) overweight status and that
this misclassification is unrelated to the factor of interest (i.e. breakfast consumption), the
results will be biased towards the null hypothesis of no difference between overweight and
normal-weight subjects. However, the analyses in this thesis did not test for differences
between overweight and normal-weight subjects, but between daily- and non-daily consumers
of breakfast. No studies were found relating underreporting of weight and BMI to breakfast
consumption, and therefore, no clear conclusion can be draw on the effect of the possible
underreporting of weight and height on the results in these thesis.

**Self-report of parental education**

The parents’ reports on own occupation and the adolescents’ reports on their parents’
occupation has showed stronger agreement than the parents’ reports on own education and the
adolescents’ report on their parents’ education (53). However, analyses on data from this
study have showed that eating behaviour was not correlated with the parents’ occupation, but
was correlated with the parents’ education (54). As breakfast is an eating behaviour, the
parents’ education was chosen as an indicator of the adolescents’ SES in this thesis, rather
than parental occupation.

Shavers (74) presented a list of strengths and limitations of using education as a measure of
SES. Two important strengths mentioned are that education is especially likely to capture
aspects of lifestyle and behaviour, in addition to being fairly stable beyond early adulthood.
Keeping in mind that in this thesis the parental education variable was made up from parents
answers from the 1996-survey (adolescents were then 19 years) combined with adolescents
answers at age 15 years, this stability in education beyond early adulthood, makes the
combination of data more acceptable. Other strengths are that education is easy to measure, that it excludes few members of the population, and also that higher education is predictive of better jobs, housing, neighbourhoods, working conditions and higher incomes. Limitations of education as an indicator of SES status include that the economic returns from the same education level may differ across racial/ethnic and gender groups, and that SES does not rise consistently with increasing years of education.

The longitudinal design spanning from adolescence to adulthood caused a challenge in using the parental education as a proxy for the participants’ SES, because the adolescents would eventually gain their own SES. However, changing the indicator of SES in the analyses would complicate the interpretation of the results by mixing the influence of SES background with that of own SES, and therefore the report on the parents’ education was kept as indicator of SES for the adolescents also for the last measurement point (age 30). However, this might have underestimated the proportion of high SES participants as recent generations are more likely to obtain a higher education.

**Self-report of physical activity**

A one-week test-retest for the duration question (hours/week) of physical activity have previously been performed among the 14-year old participants in the NLHB-study (75), and the result was a Person’s correlation coefficient of 0.89. The question on physical activity used in this thesis have previously also been tested for reliability and validity in an Australian study (76) on adolescents aged 13.1 and 15.1 years (mean ages), and in Norwegian adolescents aged 13-18 years (77). The Australian study found self-report on participation in vigorous intensity activity to have acceptable reliability and validity. In the Norwegian study the intraclass correlation coefficient for reliability of the question was found to be 0.71 (95 % CI: 0.57-0.81). The Spearman correlation coefficient for validity, measured against VO$_{2\text{peak}}$ showed fair agreement ($\kappa = 0.33; p < 0.01$). The question was found to be valid for measuring cardiorespiratory fitness (measured as VO$_{2\text{peak}}$), but not valid to measure total energy expenditure (TEE) or physical activity level (PAL) in adolescents. A review article showed that the dose-response gradient for various health outcomes is steeper across categories of cardiorespiratory fitness than across categories of physical activities (78). The authors did, however, not conclude which one of the exposure variables (cardiorespiratory fitness or
physical activity level) were the most important as a predictor of health because of measurement issues across the studies.

The physical activity variable was also used at age 19 in some analyses in this thesis, even though the question has not been validated for ages above 18 years. In adult populations self-report questionnaires on high-intensity leisure-time activity is shown to be both acceptable valid and acceptable reliable (79;80). Whereas the reproducibility and validity was shown to be lower for “light” physical activity questions. The wording of the question used to assess physical activity in the present study (“…until you are out of breath or sweat”) indicate that it is the vigorous type of physical activity it was enquired about. As it is the vigorous type of physical activity that has been shown to be most valid and reliable, it is likely that the results from the physical activity measurements in this thesis are quite trustworthy. It should, however, be noted that the question used to assess physical activity in this thesis would not be sensitive for less vigorous activity. Thus a person not participating in strenuous physical activity, but who is still being very active in terms of low intensity activity, would thus be categorized as having low levels of physical activity, when in reality total time spent at being active could be higher in this person compared to one who participate in strenuous physical activity on some occasions but is a sedentary person the rest of the time.

5.1.4 Statistical methods

When looking at the results in this thesis, it is important to bear in mind that multiple testing will give a certain amount of significant results barely by chance. For instance 1 in 20 analyses would come out as significant by chance, if the significance level is set at P \( \leq 0.05 \).

Tracking analyses

A variety of statistical methods both on a group level and on an individual level have been used to investigate tracking of dietary intake and other lifestyle variables (29;81-84). The methods are different in several aspects, including how many time points of measure allowed for in the model. The most frequently used methods of estimating tracking are correlation coefficients between subsequent measurements or the measure of the proportion of subjects staying in the same group at baseline and follow-up (30). However, also computing of subsequent mean on the basis of baseline categories for that variable has been frequently used (81;83). Most methods for assessing tracking do only allow two time points of measures in
the model, but there are more advanced methods (like General Estimation Equation (GEE)) that takes into account all the available data (from all the time points) (85). One of the advantages of GEE model estimates, is that they appropriately account for the non-independence among subjects’ measurements across years. The possibility of using GEE in this thesis was investigated, but it was found to be too advanced. The choice of method was thus made to compare means of breakfast at subsequent time points one by one to three levels of the baseline breakfast consumption. This method has been used both on tracking of dietary intake (81) and other lifestyle factors (83), and illuminated tracking of breakfast consumption on a group level in this thesis. The method allows us to get a picture of the groups’ absolute change in breakfast consumption as well as the groups’ relative change to one another. This is important in evaluating which groups, if any, is in the need of interventions (30).

Multiple regression analyses

In the multiple regression analyses, well known confounders and covariates when studying the association between breakfast consumption and BMI were adjusted for, and stratification was performed when physical activity was found to be a moderator.

Our main interest in these multiple regression analyses was to see if earlier breakfast consumption was significantly associated with BMI at age 30, also when adjusting for variables that were believed to influence this relationship. Both parental education and gender had in earlier analyses in the thesis been shown to be related to both breakfast consumption and BMI at several time points, which together strongly argued their inclusion in the multivariate model. This was also confirmed in the preliminary analyses testing for inclusion of covariates, confounders and moderators. In addition, physical activity (65;86) and dieting (87-89) was tested for inclusion, on the basis of evidence in literature for their association with both breakfast and BMI. It would be preferable to adjust for energy intake as well. However, the study did not have a variable that would properly estimate the intake.

In our study physical activity was found to be a moderator that affected the strength of the relation between breakfast consumption and BMI, giving a larger effect of breakfast on BMI in the group of low physical activity compared to the group of high physical activity, hence the splitting of the sample into these two groups. The inclusion of an interaction term in the equation was an alternative solution. However, because of the resulting limited possibility to interpret the effects of the single terms in the equation, and because our main interest in these
analyses was to understand the effect of breakfast on BMI, the alternative of stratification was chosen instead. This did, however, reduce the power of the analyses which could potentially lead to a type 2 error (not detecting an effect, when actually there is one). However, the possibility of this would only be the case for the high physical activity group, as breakfast consumption already was shown to significantly be associated with BMI in the low physical activity group. The reduced power could also affect the significance level of the associations of the other variables with BMI in the models. The focus in the discussion of the results will, however, be on the association of breakfast consumption with BMI, and its association when adjusted for possible confounders.

5.2 Discussion of main results

5.2.1 Meals – gender and stability

Both males and females had an initial decrease in frequency of consumption for all meals with age, before increasing the frequency again in young adulthood. The proportion of daily consumers of the different meals showed the same pattern. Gender differences were evident at many of the time points for all the meals, with males mainly consuming the meals more frequently compared to the females.

Regardless of the possible benefits on body weight outcomes, the decrease by age in breakfast consumption might be a concern considering the cognitive and nutritional health benefits associated with breakfast consumption in adolescence (21-25). The decrease in consumption of breakfast found in this thesis could be partly due to a possible secular trend, as some studies have indicated such a trend (27;28) in both genders equally (28). The decrease in breakfast consumption with age has been reported in other studies, both cross-sectional (27) and longitudinal ones (21;28;33;34). However, one longitudinal study on Swedish adolescents showed no change in breakfast consumption from the age of 15 to 21 years (90), with 90 % of the adolescents eating breakfast ≥ 5 times/week. The high number found in the latter study, might owe to a different consumption pattern during 5 days of the work week as compared to the whole week – analogous differences in food consumption in weekends compared to weekdays (91). In a cross-sectional study on Norwegian adolescents it was reported that 90.4 % and 83.2 % of males and females, respectively, consumed breakfast ≥ 5 times/week at age 13 (92), and the corresponding figures were 74.4 % and 78.7 %, respectively, at age 18 (93).
In a 9-year, longitudinal biracial study on females, Affenito et al. (33) reported that, approximately 53% of white girls and 35% of African-American girls ate breakfast on all of the 3 recorded days at age 13, compared to approximately 32% and 22% respectively, by age 19 years. In this thesis 74.4% and 75.3% of females and males, respectively were daily consumers of breakfast at age 13, while at age 19 the same figures were 68.3% and 67.3%, respectively. Compared to what was found by Affenito et al. (33) the Norwegian female adolescents in the NLHB-study were quite high in breakfast consumption, but they did decrease in consumption by age, and at its lowest the proportion of daily consumers was 57% at age 23 years for the males, and 57.9% at age 21 years for the females. After that, both genders increased in breakfast consumption. No other longitudinal studies were found to investigate breakfast frequency following a cohort from young adolescence into adulthood. The decrease in breakfast consumption found up until age 21 years (females) and 23 years (males) in this thesis could be related to transition periods in the adolescents’ life. A quite large decrease in daily consumers of breakfast was seen from age 15 to 18. Some of the explanation for the quantity of this change is probably the three year period in between the two measurements, as opposed to only one year in between several of the other measurements. However, part of the explanation could also be that at age 16 years, Norwegian adolescents have finished their mandatory schooling, and start working or attend upper secondary education (most chose the latter alternative). Both alternatives could possibly affect their eating pattern, and thus consumption of breakfast. One of the most frequent reason for not eating breakfast has been found to be that one do not have enough time (64), and this could be relevant in adolescents living alone for the first time or attending a upper secondary school further away from home. The increased degree of autonomy that follows living alone for the first time could result in staying up later in the evenings and sleeping longer in the morning, resulting in little time for breakfast. Also, not being hungry in the morning is a common reason for skipping breakfast (64), however, this would probably not relate to the change with age unless parents previously have required the adolescents to have some breakfast. Another frequent reason for not eating breakfast in adolescents is dieting, especially among females (87-89). In this thesis dieting was not found to be a confounder, covariate or a moderator in the multivariate analyses, and thus not effecting the interpretation of the relation between breakfast and later BMI. It could, however, be that more adolescents start dieting with age in our study, and that reducing breakfast consumption is one way of trying to loose weight. As the teenagers get older, a second transition period in the adolescents’ life may
possibly explain the further decrease in breakfast consumption at age 19. At this age the adolescents either start on a higher education, which quite a lot of Norwegians do, or they are getting a job. This is also the age when most adolescents move away from home and some of the males do their military service. Both the transition periods at ages 16 and 19 embrace a new everyday life situation with changes in food and snack availability. This as a result of for instance canteen and vending machine offerings at school and work places, as well as permission to leave the school yard during breaks. All these environmental influences could very well result in a change in food behaviours (94). This might be especially influencing the lunch meal, as this is mainly the meal consumed at work and school. The breakfast frequency started increasing again from the age of 23 and 21 for males and females, respectively. It should be noted that there is a 7-year time period in between the two last measurements, making it difficult to determine exactly how the breakfast increase proceeded. The increase may, however, be related to completion of studies, and hence a larger proportion having employment with better economic frames – this could affect food choices and behaviours. Also, in the last years of the present study it is reasonable to assume that a proportion of the sample have started a family, and possibly having young children, which in many cases would compel a more structured day with more regular meals.

The decrease in consumption with age was also seen for the other meals in this thesis. Not many studies have investigated other meals in terms of change over time. However, Sjöberg et al (22) found that it was more common that students with irregular breakfast habits omitted lunches and dinners, compared to those eating breakfast every day. If that is true, it would be expected that the consumption of the other meals dropped some in parallel with the decrease in breakfast consumption, as was found in the present thesis. In a longitudinal study of 208 Swedish adolescents (15 to 21 years of age) Von Post-Skagegård et al. (90) found that males ate lunch significantly more frequent at age 15 (4.8 times/week) compared to at age 21 (4.0 times/week), whereas the females did not change the frequency during that period (4.7 times/week). Between the age of 15 and 21 one can see from the 95 % CIs in Table 2 in the results section in this thesis, that the males have a significant decreased in frequency, going from 6.3 to 5.3 times/week in the same period, whereas the females decreased from 5.7 times/week to 5.2 with only just overlapping 95 % CI, indicating that the change for the females might be just borderline significant – resembling the findings mentioned from Von Post-Skagegård et al.
A cross-sectional study on Norwegian adolescents found 87.0 % and 81.7 % of 13-year old males and females (92), respectively, to consume lunch \( \geq 5 \) times/week, with corresponding figures for 18-year olds being 67.4 % and 66.1 % (93). In a cross-sectional study on Swedish adolescents 14-15 years of age, Höglund et al(57) reported that 49 % and 39 % of boys and girls, respectively had lunch daily. That is a quite low proportion compared to the findings in this thesis; 76.4 % and 68.0 %, respectively, at age 14 years. The present findings are, however, more in accordance with another Swedish cross-sectional study (22) that reported that 76% and 70 % of 15-16 year old boys and girls, respectively, had lunch regularly (defined as every school-day). However, the numbers are not directly comparable as the lunch in the Swedish studies was a free school lunch, as opposed to packed lunches that are the tradition in Norway, and also because the proportions presented in this thesis are for daily-consumers, as opposed to every school-day in the Swedish study.

Höglund et al.(57) also reported proportions of daily consumers of dinner to be 75 % and 62 % for Swedish 14-15 -year -old boys and girls, respectively. The same figures in the present thesis were 86.4 % and 78 %, respectively, at age 14. The adolescents in the present study are thus a little bit higher in dinner consumption compared to that found in the Swedish adolescents. In a Norwegian cross-sectional study, 91.8 % and 92.4 % of 13 year old boys and girls reported to consume dinner \( \geq 5 \) times/week, respectively (92), and the corresponding figures for the 18-year olds were 82.2 % and 83.3 % (93). Proportions being daily consumers of dinner in the NLHB-study at age 13 was found to be 84.7 % and 83.7 % for males and females, respectively, and the corresponding figures in the 18-year olds were 76.5 % and 60.5 %, respectively. In the present study dinner generally was the most frequently consumed meal. This was also reported in another Norwegian study (93), as well as in a study on US adolescents by Siega-Riz et al. (62). It should be noted that in many countries, dinner is considered the evening meal, as opposed to the tradition in Norway of having dinner after work/school hours and then consuming additional supper in the evening. In any case, youth is a period of increasing independence that includes increased opportunities to make decisions about what and when to eat. Also, in adolescence there is often an increase in time spent at school, in social, and community activities and at part-time jobs, this resulting in more time away from home, which could also affect their afternoon meal pattern.

Gender differences were found at several time points for all the meals in this thesis. Gender differences for breakfast consumption in adolescents are frequently indicated in the literature,
mostly in cross-sectional studies (22;27;57;86;92;93;95;96), but also in a few longitudinal ones (35;97). However, some of the studies seem to only describe the difference by point estimates, making it difficult to evaluate if the difference is significant (22;92;93). Common for all the studies is that they find that males eat breakfast more frequent compared to females, with the exception that the longitudinal ones (35;97) found that at the follow-up in young adulthood, males were skipping breakfast more frequent compared to females. Both these findings are in accordance with the results in this thesis. The finding that the females caught up on and surpassed the males in breakfast consumption in young adulthood, might be related to Norwegian mothers tending to stay home more frequently compared to fathers also when the children gets older, at least part time (98). It would be reasonable to think that the parent that stays home would eat breakfast with their children for practical reasons, but it could also be part of an intended educational purpose where the parent wants to influence the child to get favourable breakfast habits.

Even though studies on adolescents for the other meals are scarce, there are some studies supporting the gender differences that were found in the other meals. Høglund et al. (57) also found that more boys had lunch daily compared to girls, but Øverby et al. (99) found the opposite, that is that more girls compared to boys had lunch the day before. Høglund et al. (57) also did report a gender difference in dinner consumption, where more males compared to females had dinner. This was also indicated by Sjöberg et al. (22), but the difference found in that study did not seem to be tested for significance. In a Norwegian cross-sectional study on 13- and 18-year olds, a higher proportion of males were found to consume both breakfast, lunch and dinner ≥ 5 times/week compared to females. Again, only point estimates were given, and thus the question of significance remains. No studies exploring gender differences in supper in adolescence were found. As mentioned, supper is mostly a Norwegian practice, thus leading to a reduced research body for this meal. The pattern that males seem to consume the different meals more frequent, might partly be a result of a physiologically higher energy requirement because of a larger body mass, especially as the teenagers grow. A higher proportion of male adolescents have been found to participate in regular physical activity, compared to female adolescents (9;65), something which may also increase their need for more frequent meals. Also, dieting may be an issue in the gender differences seen in consumption of the different meals. As dieting is a frequent reason for skipping breakfast, and dieting is more common in girls compared to boys (87-89), it could be a contributing explanation for the gender differences, at least for the breakfast meal.
Only one other study was found investigating the predictive property of adolescent regular breakfast consumption on regular breakfast consumption young adult, and it was reported that regular adolescent breakfast consumption (mean age 16.1 years) significantly predicted regular breakfast consumption in young adulthood (mean age 22.5 years) (35). However, in support of the findings of tracking of breakfast consumption found in this thesis, both health and health behaviours have been shown to track from adolescence and into young adulthood, including food choices (81;83).

A positive pattern in the tracking figures in this thesis, is that those eating breakfast most rarely at age 14 also were the group that increased their frequency of breakfast intake most over the years, but they never reached the level of the highest group. This finding that the low frequency group increases their breakfast frequency over time is especially interesting considering that there was no difference in breakfast consumption between drop-outs and participants in this study. The increase among this low frequency group could be due to an increased focus in both research and media on the importance of eating breakfast in the years of this study. If this is true, it is promising to see that the information reaches the groups that need it the most. However, it could also be a result of this group being small and the phenomenon of regression towards the mean, thus having a higher impact on the mean of the group when some change in the only direction they can change, namely up (100).

5.2.2 Breakfast and weight

Both genders had a substantial increase in prevalence of overweight, starting at 5.7 % and 3.8 % of males and females being overweight at age 14 years, respectively, ending at 50.7 % and 33.3 % of males and females being overweight at age 30, respectively. It is, however, important to notice that an increase in mean BMI is expected up until adult age, this because of growth and development (40). In a longitudinal study (90) von Post-Skagegård et al. also found an increasing BMI from the age of 15 to 17 and further from 17 to 21. A biracial longitudinal study following 2379 adolescent girls from the age of 9 to 19, also reported increasing mean BMI by age (33). At each time point in the NLHB-study, the proportion of overweight males was higher than for the females, although only significant at ages 23 and 30 years. Gender differences in adolescent overweight prevalences have also been reported by others (22;57;95). The Young-HUNT study (the youth part of the Nord-Trøndelag Health Study) that used objective measures of height and weight, reported that 18.5 % and 17.9 % of
male and female 14-year olds were overweight/obese, the gender differences being not significant. That is quite high proportions, and certainly higher than what was found in this thesis (figures being 5.7 % and 3.8 % for males and females, respectively). This could be an indication of an underestimation of the overweight prevalence in the NLHB-study because of the self-report of weight and height. It should, however, be noted that the prevalences of obesity/overweight has been found to be particularly high in Nord-Trøndelag and its geographical proximity, compared to the rest of the country (101). In a longitudinal study (90) von Post-Skagegård et al. found mean BMI to be 22.9 and 22.4 for male and female 21-year olds, respectively, but the difference between genders was not significant. The same figures in this thesis were 23.2 kg/m² and 22.1 kg/m², respectively, with the gender difference being not significant. When evaluating gender differences in body weight/BMI in children and adolescence, it is important to be aware that significant gender differences are mainly found in studies using self-reported data on weight and height (102;103), not when using objective measures (9;104).

Cross-sectionally, there were no differences in mean BMI found between daily and non-daily consumers of breakfast in this thesis. This is in contrast to what have been found in several other cross-sectional studies (22;27;86;95) were skipping breakfast was associated with higher BMI or overweight, but in accordance with others (37;105). This variation in findings may be due to sample composition and methods of collecting data, as well as the different definitions of breakfast consumption being used. The prospective studies that have examined the associations between breakfast habits and body weight in adolescents report an inverse association between breakfast intake and BMI (31-36). Before stratifying on weight status (normal weight/overweight) in this thesis all groups seemed to benefit from consuming breakfast daily, when looking at mean BMI later in life; both females and males, and both when using age 14 or 19 as baseline. As mentioned in the result section, several of these results were not significant. However, this summarizes the tendencies.

In a longitudinal study, Berkley et al. (32) found that overweight breakfast skippers decreased in BMI over time (one year after) compared to overweight breakfast eaters. In normal weight subjects, however, BMI tended to increase in breakfast skippers compared to breakfast consumers (not significant though). In contrast to this, Albertson et al. (36) reported that it was those with a relative high BMI at baseline who would actually benefit from more frequent breakfast consumption in regards of a lower BMI at year 10 of the study. When
stratifying on weight status most groups in the present study benefitted from consuming breakfast daily when looking at mean BMI at subsequent ages. This was the case for both overweight and normal weight males, and when using breakfast consumption at age 14 or 19 as baseline. It was also the case for the overweight females when breakfast consumption at age 14 or 19 was applied as baseline. Finally, it also seemed to be the case for normal weight females when using breakfast consumption at age 14 as baseline. However, when applying breakfast consumption at age 19 as baseline, normal weight females did not seem to benefit from being daily consumers of breakfast in terms of the development in mean BMI, quite the opposite of the other results. Several of these results were not significant, but it summarizes the tendencies. The results from this thesis do not lend support to the findings of the two other studies by Albertson et al. (36) and Berkey et al. (32) of the variation of the importance of breakfast consumption by weight status. Again, the variation in findings may be due to differences in sample composition, methods of collecting data and statistical analyses, as well as the different definitions of breakfast consumption used. It is worth mentioning that in the overweight groups the number of subjects were very low (as seen in Table 5b and 6b), reducing the power of the analyses, and the low number also unabled the longitudinal comparison of overweight daily consumers and non-daily consumers of breakfast at age 14.

In the low physical activity group higher frequencies of breakfast at ages 14 or 19 was associated with a lower BMI at age 30. This was also true when adjusting for gender, parental education and earlier BMI. The association was, however, not found in the groups of high physical activity. In a 9 year longitudinal study of US females (ages 9 to 19), Affentino et al (33) found that more days eating breakfast was predictive of lower BMI also when controlling for study site, ethnicity and age. But the independent effect of breakfast was no longer significant after parental education, energy intake, and physical activity were added to the model. This is relevant to the results in this thesis, in the matter that no adjustments for energy intake were performed. Also, the association of baseline breakfast consumptions on later BMI could be due to the specific foods consumed at breakfast, rather than breakfast per se (21;106). Both quantity and quality of the foods consumed would be important to take in to consideration when investigating this association (106).

An explanation for the difference in importance of breakfast consumption between the low and high physical activity groups seen in this thesis, could be that the two groups might represent two groups that have different clustering of health-affecting factors. It has been
suggested that breakfast consumption might be a marker of a healthier lifestyle (21;22) – physical activity being a part of that lifestyle (24) – that could favourably influence BMI. If the high physical activity group consist of subjects that generally represent factors that are associated with lower BMI, it is reasonable that the possible independent effect of breakfast would become smaller because other factors would each contribute. Whereas for the low physical activity group, if representing a clustering of factors mainly associated with higher BMI, the independent effect that breakfast might have would probably be larger.

Another explanation might be that the group referred to as the high physical activity group could have such high levels of activity, that the breakfast consumption (regardless of frequency of consumption) becomes less important in the energy balance (the crucial point in determining body weight development). Whereas in the other group, the level of physical activity is so low, that the independent effect that breakfast might have, could become more relevant.

The impact of physical activity on the association between breakfast consumption and BMI is interesting, both considering the findings in this thesis, but also since it has been suggested by the results in the longitudinal study by Alberson et al. (36) that physical activity (and energy intake) might be a mediator(s) of the association between breakfast consumption and BMI.

5.3 Conclusions and implications for health promotion practitioners and research

5.3.1 Conclusions

Consumption of the different meals was initially decreasing in both male and female adolescents, before increasing again in young adulthood. This pattern was found both in meal frequency and for the proportion of daily-consumers of the meals. In general, the males were consuming the meals more frequently compared to the females. Tracking of breakfast was found in both genders, from the age of 14 and up until the age of 30, indicating that that breakfast habits are formed early.

Cross-sectionally there were no differences in BMI between daily and non-daily consumers of breakfast at ages 19, 21, 23 and 30. In most groups daily breakfast consumption was found to be associated with a lower BMI at subsequent time points (some significant and some non-
significant associations). This was found in both males and females, both when using age 14 or 19 as baseline, and also when stratifying on weight status at baseline. The exception was the normal weight females when using age 19 as baseline, as this group showed the opposite tendency. No difference by weight status in the benefit of consuming breakfast on BMI can be implied from these findings. In groups of low physical activity, more frequent breakfast consumption at ages 14 or 19 was found to be associated with lower BMI at age 30. This association was not found in the groups of high physical activity. The latter findings imply that the importance of consuming breakfast on future BMI, might vary by different levels of physical activity, with low physical activity groups being the ones that benefit from it.

5.3.2 Implication for practitioners

The decrease in breakfast consumption by age for both genders is worrisome as lower non-daily breakfast consumption seems to be related to an increase in later BMI, but also because of the increasing evidence of breakfast skipping’s association with other unfavourable health outcomes. For practitioners to counteract such a decrease in breakfast consumption, and also the other meals, the focus should probably be on transition periods of adolescents. This would be of importance in both genders, but especially for the females, as they generally seem to consume all meals less frequently compared to males. As breakfast was found to track from young adolescence and into adulthood, it would also be of importance to establish good breakfast habits at an early age.

More frequent breakfast consumption in adolescence was also found to be associated with BMI at age 30, but only in the in groups of low physical activity. In the light of the increasing prevalence of overweight and obesity both worldwide and nationally, the findings in this thesis could imply promotion of breakfast from an early age as part of a regime to reduce the development of these conditions by age. However, more research to confirm these findings is needed to give specific advice to practitioners.

5.3.3 Implication for further research

Tracking of breakfast from early adolescence into later adolescence and adulthood have been very little studied. There is therefore a need for more studies confirming or rejecting the findings in this thesis for stronger conclusions. If these studies are longitudinal and include several (> 2) time points of measure, it would be preferable to use a statistical method that
takes into account all the data in the analyses (such as GEE). Future studies should also replicate these tracking results in younger adolescents/children to see if it is a general phenomenon, or if the tracking is just characteristic for the age group studied in this thesis. If tracking is found also at earlier ages, interventions earlier on could shift the breakfast frequency in a healthy direction, and may thus give improved impact of interventions at older ages. Also more qualitative studies are warranted to understand how breakfast habits are established.

The reduction in breakfast consumption found in this thesis should be verified by more longitudinal studies. With regards to the decrease, research should also engage in exploring research questions such as: Why do breakfast eaters reduce their frequency by age? Is it because of increased barriers and/or lower support/motivation? More qualitative studies are needed to illuminate these questions, as well as to understand the gender differences in breakfast frequency (and the other meals). The findings from such studies could be helpful as a guidance in planning of interventions to promote breakfast consumption (and the other meals).

There was also a reduction in consumption of the other meals in this study, and its effect on health outcomes should be addressed in future studies, including their association with weight measures (e.g. BMI) later in life. Few studies have investigated the other meals in relation to weight, and even fewer are of longitudinal design. However, lately there has been some focus on total meal frequencies on this topic. It is of importance that future studies that investigate meal frequencies in relation to health outcomes (including BMI), also focus on the content of the meals, not just the frequency alone.

Daily consumption of breakfast was longitudinally associated with BMI in this thesis. Increasing breakfast frequency was longitudinally associated with BMI for groups of lower physical activity when adjusting for gender, parental education and earlier BMI, but this was not found in groups of high physical activity. The findings in this thesis should be verified in more sophisticated analyses in this study, but also in other studies. Future studies investigating breakfast frequency in relation to BMI (or other body weight measures), should investigate possible confounders not adjusted for in this thesis, such as energy intake. In this aspect more longitudinal studies are highly needed. Also, research should engage in why breakfast might have this effect on body weight: Is it just an indicator of a healthier lifestyle?
does it get metabolism started after sleep?; is quality and quantity as well as time of breakfast also important?

An odd finding in this thesis was that normal weight females did not seem to benefit from consuming breakfast daily in terms of future BMI. This finding should be confirmed by other studies to be reliable. If confirmed, a characterization of this group to explain this finding is important. Also, the result that groups of low physical activity do benefit from a more frequent breakfast, while groups of high physical activity do not benefit, should be investigated further.
6 Reference list


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## Appendix I

### Combination of parents and adolescents answers on parental education, and the collapsing into categories

To facilitate comparison of the adolescents’ answers on their parents’ education and the parents’ answers on own education, both the parents’ and the adolescents’ answers were collapsed into three categories as shown in Table A1.1. These categories (recoded values in parentheses) were renamed “Low” (1), “Middle” (2) and “High” (3) level of education for the one way ANOVA-analyses, and further collapsed to give “Low/Middle” (1) and “High” (2) level of education for the multiple regression analyses.

**Table A1.1:** Answer categories for parental education (PE) for the adolescents and the parents, and the collapsing of categories for the analyses.

<table>
<thead>
<tr>
<th>Parents answer categories</th>
<th>Adolescents answer categories</th>
<th>Categories of PE-levels used in ANOVA-analyses</th>
<th>Categories of PE-levels used in multiple regression analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 years after elementary and secondary school (9 years)</td>
<td>Elementary school (7 years) Secondary school (9 years)</td>
<td>Low level (Primary and/or secondary school)</td>
<td>Low/middle level</td>
</tr>
<tr>
<td>1-2 years after elementary and secondary school</td>
<td>Manual education Office/trade education</td>
<td>Middle level (Upper secondary school)</td>
<td></td>
</tr>
<tr>
<td>3 years after elementary and secondary school</td>
<td>Gymnasium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University/higher education</td>
<td>Less than 4 years of university/higher education More than 4 years and university/higher education</td>
<td>High level (University/college education)</td>
<td>High level</td>
</tr>
</tbody>
</table>

Cross-tabulation of parents’ answers on own education and adolescents’ answers on parental education showed that the adolescents answers gave a slight underestimation of parents with primary and secondary education, and also of parents with university/college education. Whereas for parents with upper secondary education there was a slight overestimation compared to the parents own reports. The cross-tabulation of adolescents’ and parents’ reports on parental education are shown in Table A1.2.
Table A1.2.: Cross-tabulation of parents’ and adolescents’ reports on the parents’ education.

<table>
<thead>
<tr>
<th>Parents reporting on their own education</th>
<th>Adolescents reporting on their parents education</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSMIS</td>
<td>SYSMIS 83 Other 8 Primary and secondary school 66 Upper secondary school 166 University/College 54</td>
<td>377</td>
</tr>
<tr>
<td>Other</td>
<td>3 0 1 8 1</td>
<td>13</td>
</tr>
<tr>
<td>Primary and secondary</td>
<td>7 2 15 23 2</td>
<td>49</td>
</tr>
<tr>
<td>Upper secondary</td>
<td>29 1 18 134 12</td>
<td>194</td>
</tr>
<tr>
<td>University/College</td>
<td>32 8 23 99 129</td>
<td>291</td>
</tr>
<tr>
<td>Total</td>
<td>154 19 123 430 198</td>
<td>924</td>
</tr>
</tbody>
</table>

**Breakfast frequency and parental education**

The frequency of consumption of breakfast was tested for differences in parental education by one-way analysis of variance (ANOVA). Preliminary chi-square testing showed no association between gender and parental education (P=0.606), therefore these analyses were performed on the cohort as a whole.

Table A1.3. shows the mean breakfast frequency/week for the different parental education groups, and at the different time points. Then general pattern in all three groups was an initial decrease in breakfast consumption by age, before increasing again in young adulthood. One way ANOVA-testing showed statistically significant results for the difference in breakfast consumption among the three parental education-groups at all time points but the last (age 30).
Table A1.3: Mean (95%CI) frequency of breakfast consumption in different categories of parental education in the NLHB-cohort (using combined reports from parents and adolescents on the parents’ education as an indicator of the adolescents SES):

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>The parents’ education</th>
<th>N</th>
<th>Times/week</th>
<th>N</th>
<th>Times/week</th>
<th>N</th>
<th>Times/week</th>
<th>P-value</th>
<th>Sign. difference between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary and secondary school (low, gr 1)</td>
<td></td>
<td></td>
<td>Upper secondary education (medium, gr 2)</td>
<td></td>
<td></td>
<td>University/ College (high, gr 3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>80</td>
<td>5.5 (4.9, 6.0)</td>
<td>269</td>
<td>5.7 (5.4, 6.0)</td>
<td>283</td>
<td>6.3 (6.1, 6.5)</td>
<td>0.001</td>
<td>Gr.1 and 3. Gr 2 and 3.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>101</td>
<td>5.6 (5.1, 6.1)</td>
<td>329</td>
<td>5.9 (5.6, 6.1)</td>
<td>321</td>
<td>6.4 (6.2, 6.5)</td>
<td>0.001</td>
<td>Gr.1 and 3. Gr 2 and 3.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>112</td>
<td>5.7 (5.3, 6.1)</td>
<td>348</td>
<td>5.8 (5.6, 6.0)</td>
<td>333</td>
<td>6.4 (6.2, 6.6)</td>
<td>&lt; 0.001</td>
<td>Gr.1 and 3. Gr 2 and 3.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>69</td>
<td>5.0 (4.4, 5.6)</td>
<td>253</td>
<td>5.3 (5.0, 5.6)</td>
<td>295</td>
<td>6.0 (5.7, 6.2)</td>
<td>0.001</td>
<td>Gr.1 and 3. Gr 2 and 3.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>59</td>
<td>5.0 (4.3, 5.6)</td>
<td>215</td>
<td>5.7 (5.4, 6.0)</td>
<td>262</td>
<td>6.0 (5.8, 6.2)</td>
<td>0.010</td>
<td>Gr.1 and 3.</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>59</td>
<td>4.6 (3.9, 5.3)</td>
<td>193</td>
<td>5.1 (4.7, 5.4)</td>
<td>234</td>
<td>5.7 (5.4, 6.0)</td>
<td>0.002</td>
<td>Gr.1 and 3. Gr 2 and 3.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>59</td>
<td>4.9 (4.2, 5.6)</td>
<td>205</td>
<td>4.9 (4.6, 5.3)</td>
<td>244</td>
<td>5.6 (5.3, 5.8)</td>
<td>0.014</td>
<td>Gr 2 and 3.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>46</td>
<td>5.9 (5.3, 6.5)</td>
<td>190</td>
<td>5.5 (5.2, 5.9)</td>
<td>198</td>
<td>5.8 (5.5, 6.1)</td>
<td>0.465</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Primary and secondary school = low parental education- group, Upper secondary education = middle parental education- group, University/college = high parental education- group.

b Post-hoc tests showed significant differences between specific groups (P<0.05). When the assumption of homogeneity of variance is violated (Levene’s test for homogeneity gives values of < 0.05), robust tests of equality of means are used (Welsh or Brown-Forsythe Test). Whichever of the two robust tests gives the highest p-value is the one chosen when evaluating the statistical significance of the group differences.

Post hoc-testing showed that the differences in frequency of breakfast consumption were mainly between the low and the high parental education group, and between the medium and high parental education group, with the high parental education-group being higher in frequency of breakfast consumption than the two others (low and medium). With the omission of the measurement at age 30, table A1.3 shows that the middle parental education-group also has a higher frequency of breakfast consumption at all time points compared to the low parental education group. These differences were, however, not significant.
Table A2.1.: Cross-tabulation of the independent variables tested for inclusion in the multivariable regression model. The breakfast, physical activity and BMI *-variables are from the age 14.

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Breakfast, (continuous)</th>
<th>Physical activity, (hours/week)</th>
<th>Parental education (dichotomized)</th>
<th>Dieting (dichotomized)</th>
<th>BMI, (continuous)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td>Person</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.115*</td>
<td>0.031</td>
<td>355</td>
<td>0.132*</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>382</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.059</td>
<td>0.264</td>
<td>363</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.046</td>
<td>0.552</td>
<td>172</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.037</td>
<td>0.473</td>
<td>374</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Breakfast, (continuous)</strong></td>
<td>Person</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-0.089</td>
<td>0.095</td>
<td>351</td>
<td>0.204**</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>353</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.048</td>
<td>0.547</td>
<td>158</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.133</td>
<td>0.013</td>
<td>347</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical activity, (hours/week)</strong></td>
<td>Person</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-0.124*</td>
<td>0.019</td>
<td>357</td>
<td>0.061</td>
<td>0.131*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>376</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>0.061</td>
<td>0.428</td>
<td>169</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0.131</td>
<td>0.012</td>
<td>368</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Parental education (dichotomized)</strong></td>
<td>Person</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.000</td>
<td>0.995</td>
<td>164</td>
<td>0.126</td>
<td>-0.126</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>363</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.017</td>
<td>0.017</td>
<td>356</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dieting (dichotomized)</strong></td>
<td>Person</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-0.111</td>
<td>0.149</td>
<td>172</td>
<td>-0.111</td>
<td>0.149</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>172</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.
* All BMI (body mass index, m/kg^2)-calculations were based on self-reported weight and height.
Table A2.2.: Cross-tabulation of the independent variables tested for inclusion in the multivariable regression model. The physical activity and breakfast and BMI variables are from the age 19.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Breakfast, (continuous)</th>
<th>Physical activity, (hours/week)</th>
<th>Parental education (dichotomized)</th>
<th>Dieting (dichotomized)</th>
<th>BMI, (continuous)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Person Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>0.006</td>
<td>0.067</td>
<td>0.037</td>
<td>0.036</td>
</tr>
<tr>
<td>Gender</td>
<td>444</td>
<td>0.907</td>
<td>0.207</td>
<td>0.455</td>
<td>0.609</td>
</tr>
<tr>
<td></td>
<td>353</td>
<td>0.207</td>
<td>0.455</td>
<td>0.414</td>
<td>0.201</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.182**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>Breakfast, (continuous)</td>
<td>Person Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast, (continuous)</td>
<td>1</td>
<td>-0.181**</td>
<td>0.129</td>
<td>-0.077</td>
<td>0.000</td>
</tr>
<tr>
<td>Breakfast, (continuous)</td>
<td>353</td>
<td>0.001</td>
<td>0.017</td>
<td>0.350</td>
<td>0.999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>151</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>342</td>
</tr>
<tr>
<td>Physical activity, (hours/week)</td>
<td>Person Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical activity, (hours/week)</td>
<td>1</td>
<td>-0.067</td>
<td>-0.051</td>
<td>-0.047</td>
<td>0.381</td>
</tr>
<tr>
<td>Physical activity, (hours/week)</td>
<td>353</td>
<td>0.216</td>
<td>0.531</td>
<td>0.342</td>
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<td></td>
</tr>
<tr>
<td>Parental education (dichotomized)</td>
<td>Person Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental education (dichotomized)</td>
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<td></td>
<td>0.018</td>
<td>-0.117*</td>
<td>0.032</td>
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<tr>
<td>Parental education (dichotomized)</td>
<td>414</td>
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<td>0.807</td>
<td>333</td>
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<tr>
<td>Dieting (dichotomized)</td>
<td>Person Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dieting (dichotomized)</td>
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<td></td>
<td>0.032</td>
<td>147</td>
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<td>Dieting (dichotomized)</td>
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<td>0.700</td>
<td>147</td>
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<tr>
<td>BMI, (continuous)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>BMI, (continuous)</td>
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</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

* All BMI (body mass index, m/kg²)-calculations were based on self-reported weight and height.