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The prevalence and tracking of overweight and obesity in a cohort of youths

Natural development of body mass index from childhood to adolescence

A sub study of the Fit Futures cohort

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Abstract

Objectives: The purpose of this master project was to: obtain height and weight data at three measuring points (2-4 years of age, preschool age and adolescence) in a Norwegian cohort of youths, to estimate prevalence rates of weight classes, describe the natural development of body mass index (BMI) from childhood to adolescence, and to investigate to what extent tracking of overweight and obesity was present.

Methods: In a retrospective cohort design the Fit Futures cohort was supplemented with data from childhood health records. 532 participants were included in cross sectional and longitudinal data analyses. Tracking was analysed using correlation, Cohen's weighted Kappa and logistic regression. BMI development was analysed using non-parametric tests. Descriptive data and prevalence rates for weight class, waist circumference (WC) and waist height ratio are presented (WHtR). Classification in weight classes: thin, normal weight, overweight and obese, was done according to International Obesity Taskforce age and sex specific cut-off values for children 2-18 years.

Results: 8,6 - 9,7 % of boys and 14,6 – 18,1 % of girls in childhood and 20,5 % boys and 19,7 % girls at adolescence were classified as overweight/obese. BMI decreased from 2-4 years to preschool age and increased to adolescence, following the natural change in BMI in childhood. More than 80 % stayed thin/normal weight between childhood and adolescence. Tracking of overweight/obesity was present. Being overweight/obese at preschool age increased the odds of being overweight/obese at adolescence, compared to normal/thin OR: 11,1 (CI: 6,4-19,2). Tracking of overweight/obesity between 2-4 years of age and adolescence was weaker and not significant for boys. Results of correlation and weighted Kappa analyses were in accordance with results from logistic regression. From 13,2% to 22,6 % changed their weight class between measuring points in childhood and adolescence. 19,0 % of boys and 20,9 % of girls had a WHtR ≥ 0,5, the recommended cut-off point for defining central obesity.

Conclusion: The prevalence of overweight/obesity increased with age. Prevalence rates were in accordance with earlier findings from North Norway, and are generally higher than rates reported from other regions of Norway, with some exceptions. Overall, development in BMI followed a natural growth curve and the majority stayed thin/normal weight. We found moderate to strong indication of tracking of overweight/obesity, especially from preschool age to adolescence. Tracking was strongest among girls. Many children also changed their weight class during childhood. WC and WHtR identified a higher proportion with central overweight/obesity than comparable Norwegian studies, especially among girls.

Abbreviations

ANOVA	Analyses of variance
BMI	Body mass index
CI	Confidence interval
DXA	Dual-energy X-ray absorptiometry
GLM	General Linear Model
HC	Hip circumference
HUNT	Nord-Trøndelag health survey
IOTF	International Obesity Taskforce
K_w	Cohen's weighted Kappa value
LMS	LMS curves/ LMS method: median (M), coefficient of variation (S) and skewness (L)
N/n	Number of subjects
NIPH	The Norwegian Institute of Public Health
OB	Obesity. Corresponds to an adult BMI ≥ 30
OR	Odds ratio
OWOB	Overweight including obesity. Corresponds to an adult BMI ≥ 25
P/p	The p-value, probability value.
REC	The Regional Committee for Medical and Health Research Ethics
r_s	Spearman's Rho correlation coefficient
SDS	Standard deviation score
SES	Socioeconomic status
Sig.	Significant/ significance
SPSS	Statistical Package for the Social Sciences
UNN	University Hospital of North Norway
WC	Waist circumference
WHO	The World Health Organization
WHR	Waist-hip ratio
WHtR	Waist-height ratio

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1. Introduction

1.1 Background/ previous studies

Overweight and obesity has been a growing health problem around the world for the last decades, both among adults and children. The World Health Organization (WHO) characterize the situation as an epidemic and as one of the major threats to public health both in developed and developing countries [1]. WHO Europe reported in 2007 that about 20% of children and adolescents were overweight, and a third of these were obese. 150 million adults and 15 million children in the countries of the WHO European Region were expected to be obese by 2010 [2]. Recent research suggests that the prevalence of overweight and obese children is stabilizing and plateauing, at least in some countries. However, the numbers are still high and constitute a public health concern today and for the future [3].

Even though most overweight children are well and not experiencing health problems due to excess weight, there is a higher risk of weight related illness as adults and premature death [1,2,4,5]. Overweight and obesity in childhood or adolescence are associated with increased risk of hypertension, cardiovascular diseases, diabetes type 2, musculoskeletal and pulmonary complications as well as other diseases as adults [2–4,6–9]. A systematic review and meta-analysis from 2012 concludes that overweight and obese school-aged children had significantly more unfavourable levels of risk factors (blood pressure, blood lipids levels and others) for cardiovascular disease, compared to normal weight children [6]. In addition overweight and obesity are associated with serious physical, social and psychological consequences and lower quality of life [2,9]. Childhood obesity has been described as the primary childhood health problem in developed countries [9].

There are multiple explanatory factors for the rising numbers of overweight and obese children. Influential factors span from structural changes in society like a more sedentary everyday lifestyle with lack of physical activity, more hours spent watching television, video or playing computer games and a more energy dense diet, to more individual biological causes and genetic factors that makes individuals more vulnerable to the risk of gaining weight [1,2,9–11]. A clear inverse association between socio-economic status and prevalence rates of overweight and obesity has been shown in several studies. Differences between ethnic groups, also in Norway, have also been pointed out [2,10,12]. The basic cause of overweight and obesity is an unbalance between energy intake and energy expenditure over time [9,10]. However, our modern society may also be seen as an "obesogenic" environment [2]. Thus preventive actions must address a broad spectre of factors and a multi sectorial approach is needed. The main focus has been on individuals, a healthier diet and increased physical activity. However, efforts towards a healthier society are of equal importance [2,9–11,13].

Studies from Norway have shown increasing prevalence of overweight and obesity among children and adolescents [4,14–17]. The prevalence of overweight including obesity in 8-9 year old children increased from 16 % in 2008 to 19 % in 2010. Recent published figures from The Norwegian Institute of Public Health (NIPH) shows a possible break in the increasing trend, with a prevalence rate of overweight/obesity of 15,8 % in 2012 [18]. The prevalence of obesity alone stayed stable at approximately 3,5 % in the same period [16,18]. Júlíusson et.al found a significant increase in weight for height and skinfold thickness over a 30-year period from 1971-74 to 2003-06. The prevalence of overweight and obesity respectively among 4-15 year old boys was reported to be 12,5 % and 2,1 % in boys and 14,8 % and 2,9 % in girls in measurements from 2003-06 [14]. A study from Tromsø found increasing prevalence of overweight/obesity from 1976-2001, for girls: 7,4-16,8 % [17].

Previous studies have shown that the prevalence of overweight and obesity was higher among girls than boys during childhood, but that the trend was opposite among adolescents [4,16–19]. Geographic differences in prevalence of overweight and obesity in Norway have also been revealed, with the mid and northernmost counties showing the highest numbers [16,20–24]. In the NIPH studies in 2008 and 2010 [16] the gender specific prevalence rates of overweight including obesity for the whole country were, respectively:

Age group: 8-9 year Boys: 14 % and 17 % Girls: 17 % and 22 %

Corresponding prevalence rates in the northernmost health region:

Age group: 8-9 year Boys: 16% and 22 % Girls: 22% and 24 %

Júlíusson et.al. found similar trends in the Bergen Growth study [19]:

Age group 2-5 year:	Boys: 9,6 %	Girls: 15,8 %
Age group 6-11 year:	Boys: 15,7 %	Girls: 18,4 %
Age group 12-19 year:	Boys: 12,9 %	Girls: 10,2 %

In The Young Hunt 3 study from 2006-08 [24] the prevalence of overweight/obesity was:

Age group 15-19 year: Boys: 27,0 % Girls: 25,0 %

Figures for Troms County from 2011 (self-reported data) [23] have been estimated to:

17 year olds: Boys: 14 % Girls: 13 %

Data for the northernmost counties of Norway were estimated to be 25 % in the age group 16-24 years in 2008, boys and girls combined (self-reported data) [20].

In general, there has been a lack of good and systematic national data of growth and weight development in children and adolescents in Norway [4,15]. Partly for this reason, the national guidelines for childhood measurements were revised in 2010, to be able to provide more data on this topic [25]. NIPH has earlier made a statement that there is a need for more knowledge about weight development in the Norwegian population of children, to initiate and evaluate preventive health measures [15,16].

Several studies from different countries have shown that overweight and obesity tend to be stable from adolescence to adulthood, but also from childhood to adolescence [26–33]. This is also known as tracking, see description of the term under paragraph 1.2. A study of tracking of body mass index from adolescence into adulthood has also been done in Norway [27], but we lack data for the presence and magnitude of tracking of overweight/obesity in Norwegian children [15,20]. To the best of our knowledge, no study of tracking of overweight/obesity has been done on children from North-Norway. This might be of particular interest, since prevalence rates of overweight and obesity have been reported to be highest in this region.

Studies of tracking have been done for different age groups, but the question is still whether there is a ”critical age” which can give us information about the risk of overweight in adulthood. International studies have shown that body mass index and growth curve in early infancy determines the further development in body mass index and may predict later overweight and obesity [26,33–36]. Yet, a common opinion among many is that the overweight children are most likely to loose the excess weight during childhood. It is therefore of interest to study the natural development in body mass index in a Norwegian cohort of children. This is of importance for planning public health initiatives and for evaluating effect of interventions. Lately the focus has shifted to early prevention [10,37] and the need for early intervention [38,39] to succeed in preventing and treating overweight and obesity.

This master thesis is the result of my opportunity to participate in the subproject on overweight and obesity in Fit Futures 1. Fit Futures is a cohort study of adolescents and part of The Tromsø Study [40]. The first data collection, Fit Futures 1 was conducted among students from Tromsø and the surrounding municipalities at first year of high school, the school year 2010/2011. It is a health survey with 12 sub-projects focusing on somatic health and lifestyle measurements.

1.2 Definition of central concepts:

Body mass index (BMI) is a widely used measure for overweight and obesity, commonly used both in clinical setting and in research. BMI (kg/m^2) is a crude measure and does not separate between fat and muscle mass. Waist circumference (WC), waist-height ratio (WHtR) and waist-hip (WHR) ratio are considered useful supplements to BMI as a measure for overweight or central obesity [41,42]. WHtR has been suggested to be more closely linked to childhood morbidity than BMI [42–44]. In this master project we have used both BMI and WC and WHtR to estimate the prevalence of overweight and obesity.

Tracking may be defined as stability of a certain risk factor over time or maintenance of a relative position within a distribution of values over time. It may also be defined as the predictability of future values of a risk factor from earlier measurements of risk factors [32,45,46].

A variety of definitions of overweight and obesity in children and adolescents have been used, which have made comparisons of prevalence rates difficult [7]. The International Obesity Taskforce (IOTF) has developed international age and sex specific cut-off values for overweight and obesity, based on BMI, for children aged 2-18 years. The cut-off values, also named Coles index were published in 2000 and are based on data from children in 6 countries

[7]. BMI changes naturally during growth in childhood. Figure 1.1 (Appendix 2) shows the BMI curves for girls and boys corresponding to the cut-off values for overweight and obesity. In 2007 additional cut-offs for thinness were published [47]. IOTF recommended new extended international BMI cut-off values in 2012. A benefit with the new cut-offs is that they may be expressed as standard deviation scores (BMI SDS) for analysing and comparing groups in epidemiological studies and look for trends in growth [17,48,49].

1.3 Purpose and objectives

The purpose of this master project was to: obtain height and weight data at several points in time in a Norwegian cohort of youths, describe the natural development of BMI from childhood to adolescence, and to investigate to what extent tracking of overweight and obesity was present.

More specific, the objectives of this master project were to estimate:

1. The prevalence of overweight and obesity in a cohort of youths by describing the distribution of the four weight classes, thin, normal weight, overweight and obese at two points in time in childhood (approximately 2-2,5 years and at 5-6 years of age) and one in adolescence (15-17 years of age).
2. The natural development of body mass index (BMI) from childhood to adolescence by looking at descriptive data for height, weight and BMI.
3. To what extent overweight and obesity were stable and if tracking was present from childhood to adolescence.
4. If there were any gender differences in BMI and tracking of overweight and obesity.
5. Waist circumference, waist-height ratio and waist-hip ratio as supplements to BMI as a measure for overweight or central obesity for adolescents.

2. Material and Methods.

2.1 Design

Fit Futures is a cohort study. This master project has retrospectively collected data from childhood health records to obtain longitudinal data.

2.2 Subjects/ study population

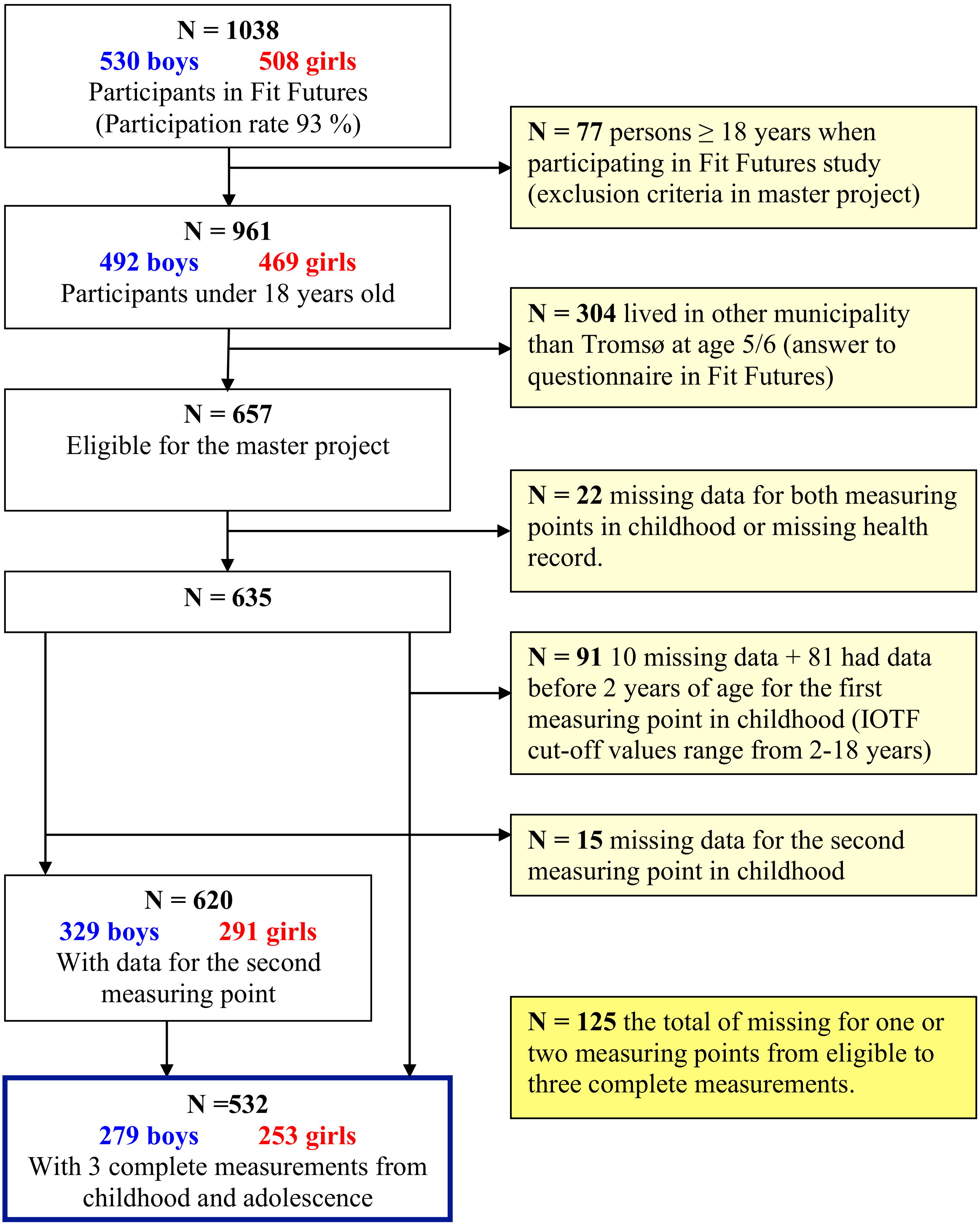
All students at first year of high school in Tromsø and Balsfjord municipalities were invited to participate in Fit Futures 1 in year 2010/2011. A total of 1038 students attended. The attendance rate was 93 percent [40]. This master project has supplemented the cohort study with data from two points in time in childhood health records.

2.2.1 Inclusion and exclusion criteria

Due to practical reasons and time limits for this master project, data collection was limited to students who reported to have been living in Tromsø municipality when they started primary school (5-6 years of age). A question of municipality of residence at that age was included in the questionnaire in Fit Futures 1. Students who were 18 years old or older, when participating in Fit Futures 1 (77 subjects), were excluded from this master project. We regarded these as adults in this context and mean values on weight and BMI for this group differed from the rest of the core age group.

A total of 961 subjects were under 18 years of age when participating in Fit Futures 1. Of these, 657 students stated that they lived in Tromsø municipality the year of starting school and were eligible for the master project. We collected data from childhood health records for 635 subjects. The flowchart (Figure 2.1.) shows the selection of the study population and reasons for exclusion or missing data.

FIGURE 2.1.
FLOWCHART: PARTICIPANTS IN FIT FUTURES/ THE MASTER PROJECT



A total number of 532 subjects, 52,4 % (279) boys and 47,6 % (253) girls, had complete measurements from all three measuring points. Results of comparison between available data for the core age group (n= 961) and the study sample are presented in Table 2.1 (Appendix 1).

Not included cases from the core age group had higher BMI and BMI SDS and WHtR (girls) at adolescence than the subjects in the study sample and the difference was significant for some of the main variables. We consider the differences to be small and the groups to be essentially the same. To ease comparisons between results in this thesis, the study sample (n= 532) was used in all the main analyses presented here.

2.3 Power calculation

A power calculation was performed using the computer program NCSS PASS 11® and a McNemar's test to help decide which sample size would be adequate to answer the questions in the protocol as well as deciding how many participants in Fit Futures, we needed to collect health record data for. McNemar's test may be used for nominal data, when looking for changes in classification or scores between persons. It compares the number, which changes their response in one direction to the number, which changes in the opposite direction [46,50]. The result of the power calculation was that a sample size of 249 pairs (meaning 249 persons examined twice) was needed to achieve a 80 % power and with a two-sided significance level of 0,05 to detect if 10 % more changed weight group in one direction compared to the opposite direction, if a difference like that existed. In the master project we had a sample size of 532 pairs in the tracking analyses.

2.4 Measurements/data

2.4.1 Data collection and quality control in Fit Futures 1

A variety of data were collected in Fit Futures 1, using different methods like questionnaires, clinical examinations and laboratory tests. In this master project we have used body weight, body height, waist and hip measurements at adolescence. We also got data for gender, age at screening and date of measurements from Fit Futures 1.

Anthropometric measures were obtained by specially trained nurses at the Clinical Research Unit at University Hospital of North Norway (UNN), following standardized procedures. Height and weight were measured to the nearest 0,1 cm and 0,1 kg on an automatic electronic scale, the Jenix DS 102 stadiometer (Dong Sahn Jenix, Seoul, Korea). Participants wore light clothing and no footwear. Waist circumference (WC) was measured twice with a measuring tape placed horizontal at umbilical level and at the end of a normal expiration. Hip circumference (HC) was measured twice at the widest portion of the buttocks. Subjects were standing with arms relaxed at sides and weight evenly distributed across feet.

2.4.2 Data collection and quality control in the master project

In the master project we collected data from childhood health records for each of the eligible participant in Fit Futures 1. In Tromsø municipality these paper based health records are archived in the city hall. Body height, body weight, age and date of measurements were collected from the health records. We collected data for two measuring points during childhood. The first measurement should be around 2-2,5 years of age and the second measuring point should be around 5-6 years of age (preschool age). If data were missing for the appropriate age/ control, we registered the nearest measurement in time and recorded the date to allow calculation of exact age at measurement. If a child had several measurements in the period around 2-2,5 years or 5-6 years, the measurement closest to the 2-year birthday or 6-year birthday, was recorded.

These measuring points were chosen because all children in Tromsø municipality in the relevant years for this study (children born 1992 – 1994) were offered health controls by public health nurses around these ages. This health control is voluntary. Regular health controls of children from birth and through school age are in accordance with national preventive health programme guidelines [25].

Height and weight measurements recorded in the health records have been performed by public health nurses as part of routine examinations and are not standardized measurements. National guidelines for height and weight measurements in public child healthcare centres are assumed to have been followed [25]. This implies, measured without shoes, with light clothing and a dry napkin. Height and weight are commonly measured to the nearest 0,1 cm and 0,1 kg and use of a digital weight is recommended. Data were recorded in the study dataset with one decimal, as recorded in the health record. We registered the date for the recorded measurement in the health record and calculated exact age from date of birth.

To minimize the possibility of punching errors, two persons performed the data collection from the childhood health records. Numbers were double-checked and proofreading was done of approximately 10 % of the data in the database and no errors were found.

2.4.3 Assessment of weight measurements

Weight measures used in this study were not adjusted for clothes. For the childhood measurements there were uncertainty if data already were adjusted or measured without clothes. Weight at adolescence was measured in light clothing as described in paragraph 2.4.1. To check what impact adjustment of weight for the adolescents would have had, we adjusted weight (minus 0,5 kg) and calculated adjusted BMI and new distribution in weight classes (data not shown). Only minor differences in BMI occurred (boys BMI: 22,1 kg/m^2 to 22,0 kg/m^2, girls BMI: 22,2 kg/m^2 to 22,0 kg/m^2). Distribution in weight classes changed less than one percentage point, except for girls where more girls went from normal weight to thin (normal weight: 74,3 % to 70,8 % and thin from 5,9 % to 9,9 %). There was no change in the percentage of obese. There has been different practice between studies, to adjust or not. Since we should compare our results both with studies that have [16,51] and don't have

[17,21,24,52] adjusted the weight measures, we decided not to. Weight measures reported are therefore crude measures.

2.5 Ethical approval and consent

Fit Futures 1, REC no. 2009/1282-4, and the protocol for the master project, REC number 2011/1284, were approved by the Regional committee for medical and health research ethics, REC North (Appendix 3). Information about the collection of data from childhood health records was described in the information leaflet used in Fit Futures 1 (Appendix 4). Both written and oral information was given and written informed consent was obtained during Fit Futures 1. Those over 16 years old at participation signed the informed consent form themselves. For students under 16 years old, additional written or oral consent from parents/guardians was obtained.

2.6 Privacy and data security

To enable data collection from the child health records for the correct subjects we were allowed temporary access to a list of names and personal identification codes for the eligible subjects in Fit Futures. Data were recorded and stored de-identified with a unique study code. All analyses have been performed on a de-identified dataset. Fit Futures as part of the Tromsø study has a licence from the Norwegian Data Inspectorate for long-term storage of data (Letter of approval, Appendix 3).

2.7 Calculating BMI and BMI Standard deviation scores (BMI SDS)

BMI was calculated as bodyweight in kg divided by height in squared meters (kg/m^2).
BMI standard deviation scores (SDS) were calculated using the LMS method and the BMI LMS coefficients corresponding to the extended international (IOTF) cut-offs from 2012. The coefficients of L (skewness), M (median) and S (coefficient of variation) curves are adjusted

for sex and age and are based on an international reference population of children [48,53]. See also paragraph 1.2. BMI SDS were calculated using the formula: $z = \frac{(BMI/M)^L - 1}{LxS}$

The calculation was done using LMSGrowth (a Microsoft Excel® add-in) [54].

BMI SDS specify how many standard deviations below or above the reference median value an individual's value is placed [17,49].

2.8 Calculating WC, WHtR and WHR

In the following the mean of the two waist and hip measurements have been used. Waist to height ratio (WHtR) was calculated as WC in cm divided by height in cm. Waist to hip ratio (WHR) was calculated as WC in cm divided by hip circumference measured in cm.

2.9 Classification in weight classes

All subjects have been classified into the weight classes: thin, normal weight, overweight and obese, at all three measuring points. Classification was based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children [48,55]. The term overweight corresponds to an adult (≥ 18 years) BMI ≥ 25 kg/m^2 – 29,99 kg/m^2. The term obese (OB) corresponds to an adult BMI ≥ 30 kg/m^2. Thin equals an adult BMI ≤ 18,5 kg/m^2. In some of the analyses the weight classes thin/normal weight are merged and overweight/obese are merged because of too few thin and obese subjects alone. The category overweight/obese (OWOB) corresponds to an adult BMI ≥ 25 kg/m^2.

In Fit Futures age is recorded as age at last birthday in full years. Age at last birthday and reference values for BMI at midyear were used to classify the children and the adolescents, as recommended by Cole et. al. [7]. For example age 5,0-5,9 was regarded 5 years old and cut-off value for 5,5 year old was used. Classification of weight class was done using LMSGrowth [54] and SPSS®.

We have compared the prevalence rates with old (2000/2007) and new cut-off values (2012) to ease later comparisons with studies that have used the old cut-off values. Table 2.2 (Appendix 1) shows the results for the comparison. Differences in classification were minor, mainly between normal weight and thin, and equals the result from the main study of the new cut-off values [48]. Thus for this master thesis, the classification with new reference values from 2012 were used.

2.10 Data analyses

Cross-sectional and longitudinal data analyses have been performed using both descriptive and analytic statistics. Statistical analyses were carried out by using IBM Statistical Package for the Social Sciences® (SPSS®) for Windows, version 19. The level of statistical significance was set to two-sided p-values < 0, 05.

Weight, BMI, BMI SDS and waist and hip measurements data in this sample were not normally distributed, except BMI for girls under 4 years of age. Both variables and residuals showed indication of deviation from normality. Shapiro-Wilk test was significant. Height was normally distributed for all groups except for girls at adolescence. Figure 2.2 and 2.3 (Appendix 2) show histograms for BMI and BMI SDS, which have a positively skewed distribution. A higher proportion than expected had an absolute z-score > 1,96 and were outliers that may affect the accuracy of the statistical models applied. For BMI z-scores 0,4-2,2 % had a z-score > 1,96, 0,4-1,6 % had a score > 2,58 and 0,7-2,5 % had a score >3,29. A natural log (LN) transformation and a log10 (Lg10) transformation of the BMI data were tested. These transformations can correct for positive skew and unequal variances [50](page 153-156). New analyses on the transformed data did not correct the problem or change the results. To overcome this problem, even though we have a big sample (n > 500), we have chosen to preform tests that do not assume normally distributed data, like Spearman's Rho correlation, logistic regression with categorical variables and non-parametric tests [50].

Development in mean BMI and BMI SDS from childhood to adolescence was analysed using Friedman's ANOVA for repeated measures. Post hoc tests were conducted using Wilcoxon signed-rank test for comparing two sets of scores (means) coming from the same participants (the non-parametric equivalent of the dependent t-test) and Mann-Whitney U test for comparing different groups (the non-parametric equivalent of the independent t-test) [50]. The p-values were calculated with the Monte Carlo method and a stricter confidence level of 99 % ($p < 0,01$) was used (and are reported) to account for the fact that these measurements were repeated measures for the same people and correcting for multiple comparisons [50]. This is comparable with the Bonferroni correction method that is applied in the General linear model (GLM) for repeated measures design.

The Figures 3.1-3.3 a-b showing development in BMI and BMI SDS, shows adjusted mean values to correct for repeated measures of the same individuals (adjusted with an adjustment factor to eliminate between subjects difference). The means are the same, but standard error and hence SD is smaller to get correct error bars [50](page 317-324). Table 3.16 and 3.17 (Appendix 1) shows mean values and adjusted mean values and SD.

Tracking is often analysed using more than one method and several methods may be used [45,46,56]. In this study four methods have been used: Spearman's Rho correlation, McNemar's test for related samples, Cohen's weighted Kappa and logistic regression analyses. The different analyses provide somewhat different information or were used to confirm the findings. McNemar's test was done because it was used in the power calculation, explained in paragraph 2.3.

The proportion of agreement was also calculated, i.e. children that remained in their weight class from measuring point I to measuring point II and III and from measuring point II to III. This was compared with the expected proportions by chance (no tracking) [46,56,57]. The expected proportion of no tracking was in this study assumed to be the same distribution at measuring point II or III as at measuring point I or II. These proportions were calculated in 4x4 contingency tables. The expected proportions agreeing were found as in Chi-squared tests, by row total times column total divided by grand total [57]. To test the observed proportions of agreement with the proportions expected by chance, we used Cohen's weighted Kappa. In weighted Kappa analyses for ordinal variables, more dissimilar values are weighted more heavily than more similar values [58], so a child changing weight class from underweight to overweight is weighted more heavily than a child changing from normal weight to overweight between two points in time. Weighted Kappa analysis is not directly available in SPSS® but a syntax file made available at IBM® Support Portal [58] was used. We have used a set of weights that are based on the squared distance between categories [58] according to Fleiss and Cohen 1973 [59] and used in comparable studies of tracking [56].

There has not been any consensus in how to interpret the Kappa coefficient, and interpretation must be done with caution [46,57]. We have used the guidelines by Munoz and Bangdiwala [57,60]. Value of Kappa – strength of agreement: < 0.00 – poor, 0.00-0.20 – fair, 0.21-0.45 moderate, 0.46-0.75 substantial, and 0.76-1.00 – almost perfect.

Tracking was also analysed using logistic regression to be able to adjust for covariates. Logistic regression analyses between pairwise examinations were done, using forced enter method. Tracking was estimated by the odds ratio (OR) of being OWOB at measuring point II or III according to weight class at measuring point I or II. In the model, both dependent and independent variables were dichotomised into weight class thin/normal weight or OWOB. Age at measuring point I or II, gender and time between measuring points (in years, months) were included as covariates in the analyses and to test for interactions and confounders. Mean timespan between measuring point I and II was 3,4 years, 14,0 years between I and III and 10,6 years between II and III. The number of children with obesity was too small to test each weight class separately.

Gender differences were examined using Mann-Whitney U test for comparing different groups (the non-parametric equivalent of the independent t-test) and verified by independent samples t-test for equality of means. Chi square tests were performed in 2x3 or 2x2 tables or separate analyses for boys and girls were done.

Presenting of results and terms used

Results for three age groups (measuring points) are presented: 2-4 years of age, preschool age and adolescence. The term childhood is used as a collective term for the first two age groups. The term youths are used for all children/adolescents in the study sample.

Results of tests for gender differences are presented consecutively under each description of main test results.

3. Results

3.1 Descriptive data for bodyweight, body height, BMI and BMI SDS.

Table 3.1 shows age, height, weight, BMI and BMI SDS, mean and standard deviation (SD) per sex and age group. Table 3.13-3.15 (Appendix 1) shows more detailed descriptive data for the same variables in the same groups. BMI and BMI SDS are described in paragraph 3.3.

Height and weight were increasing with age, as expected. Boys were significantly higher and weighed more than the girls, in all age groups. However, in childhood the differences were small. At adolescence the difference in height and weight had increased and difference in mean height was 11,8 cm, difference in mean weight was 8,9 kg between boys and girls.

Table 3.1. Descriptive data for age, height, weight, BMI and BMI SDS[1] for three age groups

Variables		Boys				Girls			
		Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
2 - 4 years of age	Age (years)	2,6	0,23	2,0	3,9	2,6	0,20	2,0	3,5
	Body height (cm)	93,0 [2]	3,91	83,0	104,0	91,3 [2]	3,50	81,0	103,0
	Body weight (kg)	14,1 [2]	1,63	10,4	22,0	13,5 [2]	1,57	9,9	19,0
	BMI kg/m^2	16,33	1,35	12,72	22,45	16,19	1,38	12,91	20,62
	BMI SDS	0,01	1,01	-3,39	3,63	0,08	1,00	-2,81	2,70
Preschool age	Age (years)	6,0	0,36	5,2	7,2	6,0	0,38	4,1	7,0
	Body height (cm)	117,8 [2]	5,09	101,0	135,0	116,1 [2]	5,03	100,5	132,0
	Body weight (kg)	22,0 [3]	3,56	15,7	38,5	21,6 [3]	4,02	15,0	39,0
	BMI kg/m^2	15,77	1,77	12,82	25,53	15,96	2,10	12,78	25,77
	BMI SDS	0,14 [3]	0,94	-2,14	3,61	0,33 [3]	1,06	-2,08	3,90
Adolescence	Age (years)	16,0	0,39	15,0	17,0	16,1	0,37	15,0	17,0
	Body height (cm)	177,0 [2]	6,64	159,6	196,6	165,2 [2]	6,35	146,5	187,1
	Body weight (kg)	69,5 [2]	14,75	43,6	136,5	60,6 [2]	11,82	39,8	114,1
	BMI kg/m^2	22,14	4,29	16,05	42,87	22,22	4,14	16,19	41,16
	BMI SDS	0,49	1,12	-2,08	3,62	0,40	1,03	-2,05	3,36
	N	279				253			

[1] BMI SDS is calculated using new extended LMS values from IOTF 2012 based on an international reference population of children. All gender diff. tested with Mann-Whitney U test for comparing different groups.
[2] $p < 0.001$
[3] $p = 0.03$.

3.2 Weight classes

Table 3.2. Prevalence of thin, normal weight, overweight and obese · (number and %) for the three age groups. Boys and girls separately and combined (All)

		Thin n (%)	Normal weight n (%)	Overweight n (%)	Obese n (%)	n (%)
2 - 4 years of age	Boys [1]	41 (14,7)	214 (76,7)	20 (7,2)	4 (1,4)	279 (100,0)
	Girls [1]	37 (14,6)	179 (70,8)	33 (13,0)	4 (1,6)	253 (100,0)
	All	78 (14,7)	393 (73,9)	53 (10,0)	8 (1,5)	532 (100,0)
Preschool age	Boys [2]	21 (7,5)	231 (82,8)	18 (6,5)	9 (3,2)	279 (100,0)
	Girls [2]	27 (10,7)	180 (71,1)	32 (12,6)	14 (5,5)	253 (100,0)
	All	48 (9,0)	411 (77,3)	50 (9,4)	23 (4,3)	532 (100,0)
Adolescence	Boys [3]	27 (9,7)	195 (69,9)	37 (13,3)	20 (7,2)	279 (100,0)
	Girls [3]	15 (5,9)	188 (74,3)	37 (14,6)	13 (5,1)	253 (100,0)
	All	42 (7,9)	383 (72,0)	74 (13,9)	33 (6,2)	532 (100,0)

* Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]
All Pearson Chi-Square tests for gender differences in weight classes were performed in a 2x3 contingency table with weight class overweight/obese merged due to few obese participants.
[1] P=0.09, [2] P=0.01, [3] P=0.25

Table 3.2 shows prevalence rates of thin, normal weight, overweight and obesity for boys and girls and tests for gender differences for the three age groups. The majority of both boys and girls in all three age groups were classified as normal weight. The prevalence of overweight/obesity (OWOB) increased with age.

For boys 2-4 years of age 8,6 % were classified as OWOB and 1,4 % as obese (OB). For girls 2-4 years of age 14,6 % were classified as OWOB and 1,6 % as OB. In this age group, more boys were classified as thin (14,7 %) than as OWOB (8,6 %).

At preschool age, 9,7 % of the boys were classified as OWOB and 3,2 % as OB. Among girls 18,1 % were classified as OWOB and 5,5 % as OB. In this age group, more children, were classified as OWOB (13,7 %) than thin (9,0 %).

At adolescence, 20,5 % of the boys were classified as OWOB and 7,2 % as OB. Among girls at same age 19,7 % were classified as OWOB and 5,1 % as OB. As adolescents, more than double as many, both boys and girls were classified as OWOB (20,1 %) than thin (7,9 %).

More girls than boys were classified as OWOB in childhood. But the gender difference in weight class distribution was not significant, except for at preschool age where almost twice as many girls 18,1 % than boys 9,7 % were OWOB. Pearson Chi square test p = 0.01. At adolescence this trend has turned a bit and more boys than girls were classified as OWOB, but the gender difference was not significant.

3.3 Development of BMI and BMI SDS from childhood to adolescence

Mean BMI decreased from 2-4 years of age, boys: 16,33 kg/m^2, girls: 16,19 kg/m^2, until preschool age, boys: 15,77 kg/m^2, girls: 15,96 kg/m^2. Mean BMI increased from childhood to adolescence. Mean BMI for the adolescents, boys: 22,14 kg/m^2, girls: 22,22 kg/m^2. See Table 3.1, page 20 and Figure 3.1.

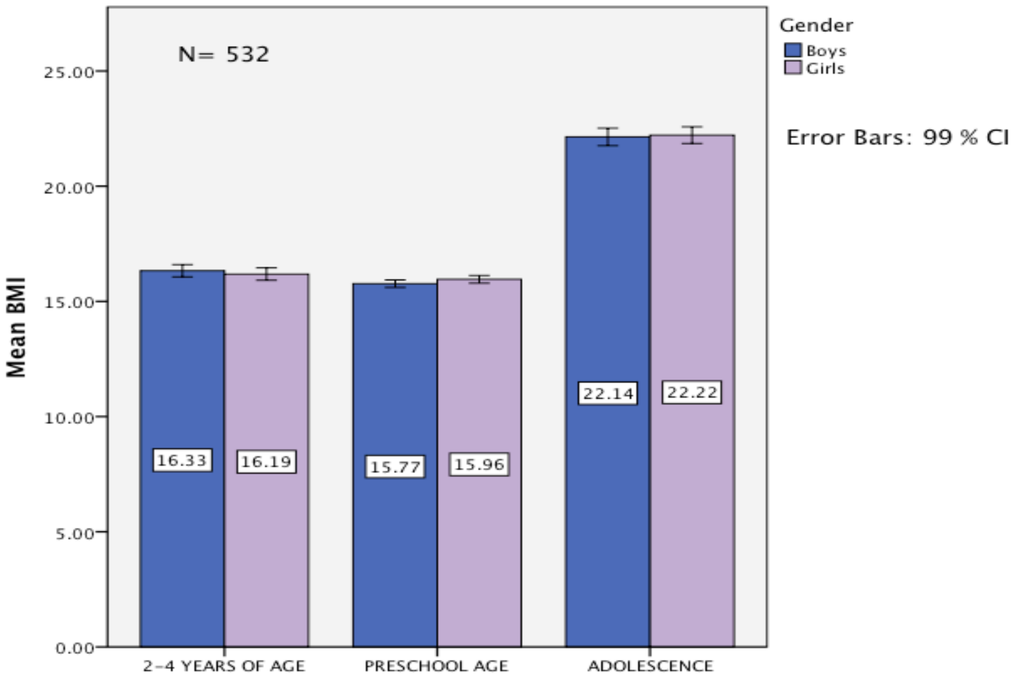


Figure 3.1. Mean BMI and 99 % CI at three measuring points, split by gender

Post-hoc test, Wilcoxon signed-rank test, was significant, $p < 0{,}001$, for difference in BMI between all three measuring points. No significant gender differences in mean BMI were found in any of the age groups.

Mean BMI SDS increased with age. When analysing change in BMI SDS from childhood to adolescence for girls and boys combined, we found that BMI SDS increased significantly between each age group. Friedman's Anova overall test and post-hoc test was significant $p < 0{,}001$. The development in BMI SDS was somewhat different between boys and girls. See Figure 3.2 and Table 3.3. Mean BMI SDS were higher among girls than boys in childhood. At adolescence this had shifted. Post-hoc test, Wilcoxon signed-rank test, was significant between each measuring point for the boys. For the girls the change was significant between 2-4 years and preschool age and 2-4 years and adolescence, but not between preschool age and adolescence. The gender difference was only significant at preschool age.

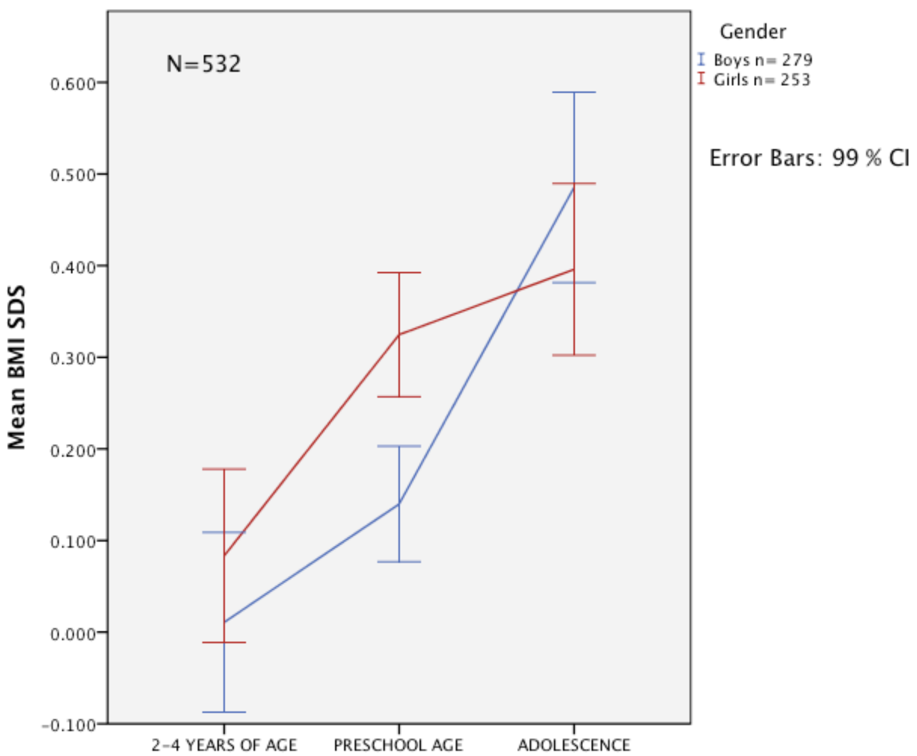


Figure 3.2. Mean BMI SDS and 99 % CI at three measuring points split by gender

To look more closely into what was normal development of BMI and BMI SDS from childhood to adolescence, we analysed the change only for those who were normal weight at all three measuring points (subgroup A n= 263). In addition we wanted to see if there was any difference in BMI and BMI SDS development between those who were normal weight and overweight/obese (OWOB). Because only few children stayed overweight or obese at all three measuring points, the analyses were done only between preschool age and adolescence, comparing those who were normal weight with those who were OWOB at both ages (subgroup B n = 366). Table 3.3 shows mean *change* in BMI SDS for three different groups, all in the study sample n= 532, subgroup A n= 263 and subgroup B n= 366, separate for boys and girls and combined (All). Table 3.4 shows mean *change* in BMI for subgroup B. Figure 3.3 a) shows mean BMI for subgroup B and Figure 3.3 b) shows mean BMI SDS for subgroup B. Table 3.16 and 3.17 (Appendix 1) shows mean values showed in the Figures 3.1-3.3 a-b.

Table 3.3. Mean change in BMI SDS for three different subgroups from two measuring points in childhood to adolescence

MEAN CHANGE IN BMI SDS (95 % CI)			
	All	Boys	Girls
ALL IN THE STUDY SAMPLE N= 532			
2-4 years age to Preschool age	0,18 [3] (0,10 to 0,27)	0,13 [4] (0,01 to 0,25)	0,24 [3] (0,12 to 0,37)
2-4 years age to Adolescence	0,40 [3] (0,28 to 0,52)	0,47 [3] (0,30 to 0,65)	0,31 [3] (0,15 to 0,48)
Preschool age to Adolescence	0,22 [3] (0,12 to 0,31)	0,35 [3] (0,21 to 0,48)	0,07 [5] (-0,05 to 0,20)
N	532	279	253
SUBGROUP A - NORMAL WEIGHT AT ALL THREE AGES			
2-4 years age to Preschool age	0,02 [5] (-0,06 to 0,11)	-0,05[5](-0,17 to 0,07)	0,11 [4] (-0,01 to 0,23)
2-4 years age to Adolescence	0,14 [6] (0,03 to 0,25)	0,19 [6] (0,03 to 0,35)	0,09 [5](-0,06 to 0,25)
Preschool age to Adolescence	0,12 [7] (0,02 to 0,21)	0,24 [3] (0,11 to 0,36)	-0,02[5](-0,16 to 0,12)
N	263	141	122
SUBGROUP B - NORMAL WEIGHT OR OWOB AT BOTH PRESCHOOL AND ADOLESCENCE			
Preschool age to Adolescence:			
Normal weight n= 320 [1 8]	0,14 [3] (0,07 to 0,21)	0,26 (0,17 to 0,35)	0,00 (-0,10 to 0,10)
Overweight/obese n= 46 [2 8]	0,04 [5] (-0,17 to 0,26)	0,10 (-0,35 to 0,55)	0,01(-0,22 to 0,25)
N	366		

[1] Boys n= 170, girls n= 150, [2] Boys n= 17, girls n= 29
Wilcoxon signed-rank test [3] p < 0,001, [4] p= 0.03, [5] p= not significant, [6] p=0.001, [7] p=0.003
[8] Mann-Whitney U test for comparison between groups, p < 0,001.

Table 3.4. Mean change in BMI between preschool age and adolescence for those who were normal weight or OWOB at both preschool age to adolescence Subgroup B.

MEAN CHANGE IN BMI (95 % CI)			
	All	Boys	Girls
Preschool to Adolescence:			
Normal weight n= 320 [1 4]	5,48 [3](5,31 to 5,65)	5,51 (5,27 to 5,74)	5,45 (5,21 to 5,70)
Overweight/obese n= 46 [2 4]	10,56[3](9,28 to 11,85)	11,15 (8,56 to 13,74)	10,22 (8,73 to 11,71)
N	366	187	179

[1] Boys n= 170, girls n= 150, [2] Boys n= 17, girls n= 29
[3] Wilcoxon signed-rank test p < 0,001.
[4] Mann-Whitney U test for comparison between groups, p < 0,001

Among those who were normal weight at all three ages (subgroup A) BMI followed the same pattern as for the whole group, like in Figure 3.1. Mean BMI was significantly different between all ages. Friedman's Anova and post-hoc test, Wilcoxon signed-rank test, were significant, p ≤ 0,001. No gender differences. Data not shown.

Among the same group of normal weight at all three ages, BMI SDS increased with age, but the development was different between boys and girls. Among boys, BMI SDS significantly increased between both measuring points in childhood to adolescence. Mean BMI SDS among boys: 0,10 - 0,05 - 0,29. The changes are shown in Table 3.3. Both Friedman's Anova and Wilcoxon signed-rank test were significant, p ≤ 0,001. The decrease in BMI SDS (-0.05) between 2-4 years of age and preschool age was not significant. Among girls mean BMI SDS were: 0,05 - 0,16 - 0,14. The increase in BMI SDS (0.11) from 2-4 years of age to preschool age was significant. Wilcoxon signed-rank test p = 0,03. The changes in BMI SDS from both measuring points in childhood to adolescence were not significant. See Table 3.3.

For subgroup B, BMI increased significantly in both groups from preschool age to adolescence. BMI among those who were normal weight: 15,4 - 20,9 kg/m^2, change: 5,5 kg/m^2. BMI among those who were overweight/obese: 20,2 - 30,8 kg/m^2, change: 10,6 kg/m^2. Wilcoxon signed-rank test p < 0,001. BMI was significantly higher among the overweight/obese at both ages. Mann-Whitney U test for comparison between groups, p < 0,001. See Table 3.4 and Figure 3.3 a).

Also in subgroup B, BMI SDS increased from preschool age to adolescence. This change was significant only for those who were normal weight at both ages, BMI SDS 0,08 – 0,22, change: 0,14. Wilcoxon signed-rank test p < 0,001. The change for those who were overweight/obese at both ages was small and not significant, BMI SDS 2,25 – 2,29, change: 0,04. The two weight groups were significantly different at both ages. Mann-Whitney U test for comparison between groups p < 0,001. See Table 3.3 and Figure 3.3 b).

The normal weight boys BMI SDS increased between preschool age and adolescence (0,26), the girls BMI SDS were stable (0,00). The overweight/ obese boys and girls did not significantly differ in development of BMI SDS from preschool age to adolescence (boys: 0,10, girls: 0,01) The number in this group of OWOB was small: 17 boys and 29 girls, so interpretation must be done with caution. The difference in BMI SDS development among those who were normal weight at both ages was in accordance with the result in subgroup A.

Development of BMI and BMI SDS has also been tested with General linear model with repeated measures design and the results were equal to the results of the non-parametric tests, but p-values might differ. Development in BMI and BMI SDS has been looked at in several ways, e.g. by splitting by weight class thin/normal weight and OWOB at preschool age. The line diagram shows the tracking pattern, but also the change in weight class during childhood (A somewhat decreasing trend among OWOB, a somewhat increasing trend among normal weight/thin) (data not shown). This has also been tested with analyses of tracking and will be further described in paragraph 3.4.

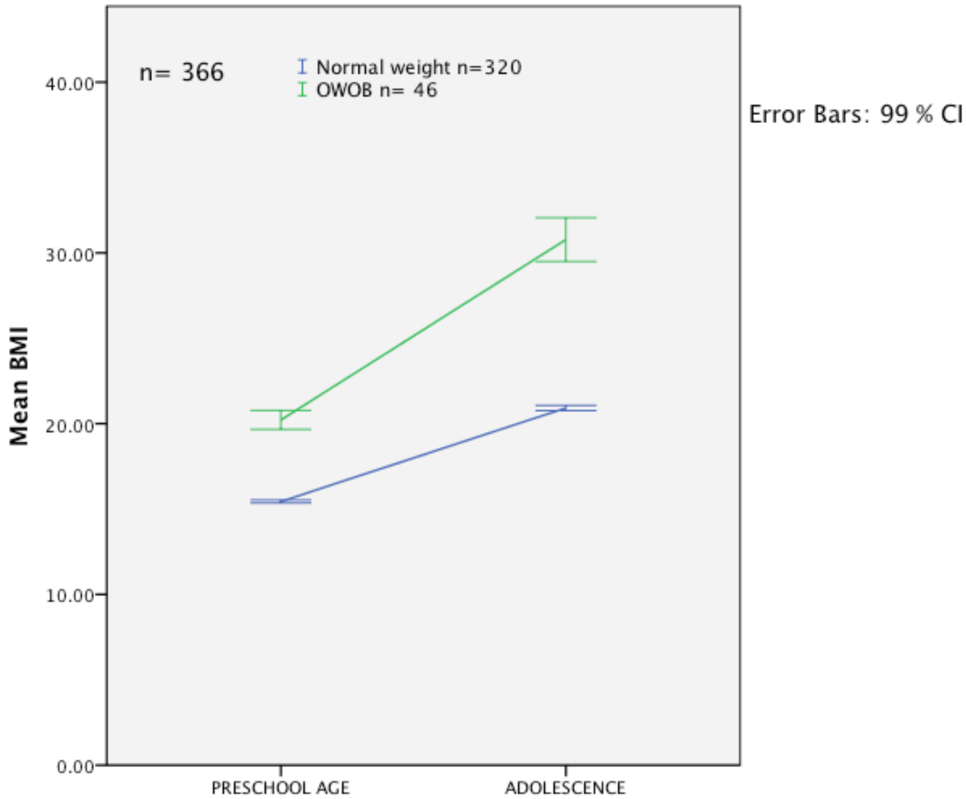


Figure 3.3 a) **Mean BMI at preschool age and adolescence split by those who were normal weight or OWOB at both measuring points.**

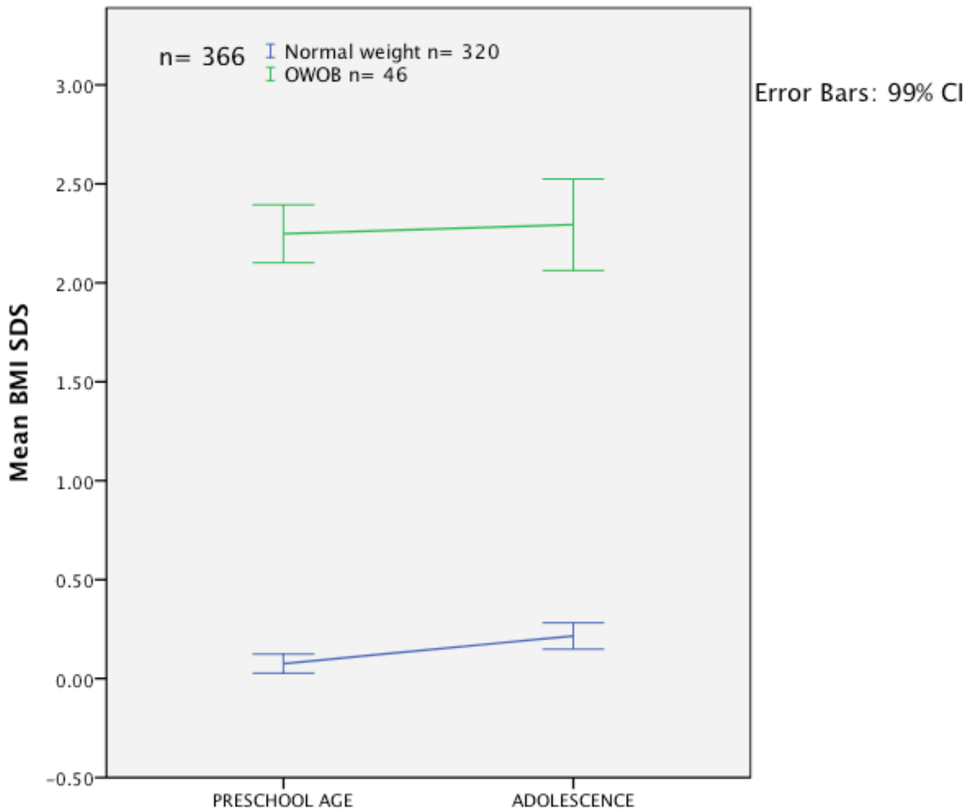


Figure 3.3 b) **Mean BMI SDS from preschool age to adolescence for those who were normal weight or OWOB at both measuring points.**

3.4 Results from analyses of tracking of overweight and obesity

3.4.1 Correlation of BMI

Spearman's Rho correlation coefficient (r_s) for BMI is reported. All correlations were highly significant p < 0,001.

BMI in childhood positively correlated with BMI at adolescence. For measurements 2-4-years of age to adolescence r_s = 0,39 (boys: 0,36, girls:0,42). For preschool measurements to adolescence r_s = 0,63 (boys: 0,60, girls:0,66). There was also a strong correlation between BMI at 2-4 years of age and preschool age, r_s = 0,66 (boys: 0,65, girls:0,68).

3.4.2 Stability and change of weight class between pairwise measurements

Table 3.5-3.7 shows cross tabulation of weight classes dichotomised into thin/normal weight and overweight/obese between pairwise measurements. Percentages and numbers are shown for boys and girls separately and combined (All).

Table 3.5. Distribution in weight classes thin/normal weight and overweight/obese at preschool age by 2-4 years of age in percentages and numbers for boys and girls separately and combined (All)

Weight class 2 - 4 years of age			Weight class preschool age		Total column % (n)
			Thin/normal weight row % (n)	Overweight/obese row % (n)	
	BOYS	Thin/normal weight	92,9 (237)	7,1 (18 [1])	**91,4 (255)**
		Overweight/obese	62,5 (15 [1])	37,5 (9)	**8,6 (24)**
		Total row % (n)	90,3 (252)	9,7 (27)	**100,0 (279)**
	GIRLS	Thin/normal weight	89,4 (193)	10,6 (23 [2])	**85,4 (216)**
		Overweight/obese	37,8 (14 [2])	62,2 (23)	**14,6 (37)**
		Total row % (n)	81,8 (207)	18,2 (46)	**100,0 (253)**
	ALL	Thin/normal weight	91,3 (430)	8,7 (41 [2])	**88,5 (471)**
		Overweight/obese	47,5 (29 [2])	52,5 (32)	**11,5 (61)**
		Total row % (n)	**86,3 (459)**	**13,7 (73)**	**100,0 (532)**

McNemar's test [1] p = 0,73 [2] p = 0,19
Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]

Table 3.6. Distribution in weight classes thin/normal weight and overweight/obese at adolescence by 2-4 years of age in percentages and numbers for boys and girls separately and combined (All)

Weight class 2 - 4 years of age		Weight class adolescence: Thin/normal weight row % (n)	Weight class adolescence: Overweight/obese row % (n)	Total column % (n)
BOYS	Thin/normal weight	80,8 (206)	19,2 (49 [1])	**91,4 (255)**
	Overweight/obese	66,7 (16 [1])	33,3 (8)	**8,6 (24)**
	Total row % (n)	79,6 (222)	20,4 (57)	**100,0 (279)**
GIRLS	Thin/normal weight	84,3 (182)	15,7 (34 [2])	**85,4 (216)**
	Overweight/obese	56,8 (21 [2])	43,2 (16)	**14,6 (37)**
	Total row % (n)	80,2 (203)	19,8 (50)	**100,0 (253)**
ALL	Thin/normal weight	82,4 (388)	17,6 (83 [1])	**88,5 (471)**
	Overweight/obese	60,7 (37[1])	39,3 (24)	**11,5 (61)**
	Total row % (n)	**79,9 (425)**	**20,1 (107)**	**100,0 (532)**

McNemar's test [1] p < 0,001 [2] p = 0,11
Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]

Table 3.7. Distribution in weight classes thin/normal weight and overweight/obese at adolescence by preschool age in percentages and numbers for boys and girls separately and combined (All)

Weight class preschool age		Weight class adolescence: Thin/normal weight row % (n)	Weight class adolescence: Overweight/obese row % (n)	Total column % (n)
BOYS	Thin/normal weight	84,1 (212)	15,9 (40 [1])	**90,3 (252)**
	Overweight/obese	37,0 (10 [1])	63,0 (17)	**9,7 (27)**
	Total row % (n)	79,6 (222)	20,4 (57)	**100,0 (279)**
GIRLS	Thin/normal weight	89,9 (186)	10,1 (21 [2])	**81,8 (207)**
	Overweight/obese	37,0 (17 [2])	63,0 (29)	**18,2 (46)**
	Total row % (n)	80,2 (203)	19,8 (50)	**100,0 (253)**
ALL	Thin/normal weight	86,7 (398)	13,3 (61[1])	**86,3 (459)**
	Overweight/obese	37,0 (27 [1])	63,0 (46)	**13,7 (73)**
	Total row % (n)	**79,9 (425)**	**20,1 (107)**	**100,0 (532)**

McNemar's test [1] p < 0,001 [2] p = 0,63
Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]

When looking at the three contingency tables, ≥ 80 % stayed in the categories thin/normal weight between any two measuring points. Among all overweight/obese (boys and girls combined) 52,5 % stayed overweight/obese between 2-4 years of age and preschool age.

63,0 % stayed overweight/obese between preschool age and adolescence. Overall (boys and girls combined) between 13,2-22,6 % changed their weight class between any two measuring points. The highest percentage change was between 2-4 years of age and adolescence, where 22,6 % changed between the two weight classes and only 39,3 % of the overweight/obese stayed overweight/obese between these two measuring points.

When we look at these children who changed weight class between childhood and adolescence, significantly more changed from thin/normal weight to overweight/obese, than vice versa and McNemar's test was significant, $p < 0.001$, for both measurements in childhood to adolescence. Separate analyses for boys and girls showed that McNemar's test only was significant for the boys. Between 2-4 years of age and preschool age the numbers that changed between the two weight classes were more equal and McNemar's test was not significant.

The McNemar's test compares counts, not proportions. So, when looking at the normal weight group compared to the overweight/obese group, the picture become quite different. The proportion of overweight/obese children who became normal weight was higher than the proportion of normal weight that became overweight/obese. The picture was the same both among boys and girls and between any two measuring points. See row percentages in Table 3.5 -3.7.

3.4.3 Proportions of agreement and Cohen's Weighted Kappa analyses

Table 3.8-3.10 shows cross tabulation of weight classes in four classes between pairwise measurements. Percentages and numbers are shown for boys and girls separately and combined (All).

Table 3.8. Distribution in four weight classes at preschool age by 2-4 years of age in percentages and numbers for boys and girls separately and combined (All)

Weight class 2 - 4 years of age		Weight class preschool age: Thin % row (n)	Normal weight % row (n)	Overweight % row (n)	Obese % row (n)	Total % column (n)
BOYS	Thin	31,7 (13)	68,3 (28)	0,0 (0)	0,0 (0)	14,7 (41)
	Normal weight	3,7 (8)	87,9 (188)	7,0 (15)	1,4 (3)	76,7 (214)
	Overweight	0,0 (0)	70,0 (14)	15,0 (3)	15,0 (3)	7,2 (20)
	Obese	0,0 (0)	25,0 (1)	0,0 (0)	75,0 (3)	1,4 (4)
	Total row % (n)	7,5 (21)	82,8 (231)	6,5 (18)	3,2 (9)	100,0 (279)
GIRLS	Thin	45,9 (17)	48,6 (18)	5,4 (2)	0,0 (0)	14,6 (37)
	Normal weight	5,6 (10)	82,7 (148)	7,8 (14)	3,9 (7)	70,8 (179)
	Overweight	0,0 (0)	42,4 (14)	42,4 (14)	15,2 (5)	13,0 (33)
	Obese	0,0 (0)	0,0 (0)	50,0 (2)	50,0 (2)	1,6 (4)
	Total row % (n)	10,7 (27)	71,1 (180)	12,6 (32)	5,5 (14)	100,0 (253)
ALL	Thin	38,5 (30)	59,0 (46)	2,6 (2)	0,0 (0)	14,7 (78)
	Normal weight	4,6 (18)	85,5 (336)	7,4 (29)	2,5 (10)	73,9 (393)
	Overweight	0,0 (0)	52,8 (28)	32,1 (17)	15,1 (8)	10,0 (53)
	Obese	0,0 (0)	12,5 (1)	25,0 (2)	62,5 (5)	1,5 (8)
	Total row % (n)	9,0 (48)	77,3 (411)	9,4 (50)	4,3 (23)	100,0 (532)

Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]

Table 3.9. Distribution in four weight classes at adolescence by 2-4 years of age in percentages and numbers for boys and girls separately and combined (All)

Weight class 2 - 4 years of age		Weight class adolescence: Thin % row (n)	Normal weight % row (n)	Overweight % row (n)	Obese % row (n)	Total % column (n)
BOYS	Thin	24,4 (10)	63,4 (26)	4,9 (2)	7,3 (3)	14,7 (41)
	Normal weight	7,5 (16)	72,0 (154)	14,0 (30)	6,5 (14)	76,7 (214)
	Overweight	5,0 (1)	70,0 (14)	10,0 (2)	15,0 (3)	7,2 (20)
	Obese	0,0 (0)	25,0 (1)	75,0 (3)	0,0 (0)	1,4 (4)
	Total row % (n)	9,7 (27)	69,9 (195)	13,3 (37)	7,2 (20)	100,0 (279)
GIRLS	Thin	16,2 (6)	75,7 (28)	8,1 (3)	0,0 (0)	14,7 (41)
	Normal weight	5,0 (9)	77,7 (139)	12,8 (23)	4,5 (8)	76,7 (214)
	Overweight	0,0 (0)	60,6 (20)	27,3 (9)	12,1 (4)	7,2 (20)
	Obese	0,0 (0)	25,0 (1)	50,0 (2)	25,0 (1)	1,4 (4)
	Total row % (n)	5,9 (15)	74,3 (188)	14,6 (37)	5,1 (13)	100,0 (253)
ALL	Thin	20,5 (16)	69,2 (54)	6,4 (5)	3,8 (3)	14,7 (78)
	Normal weight	6,4 (25)	74,6 (293)	13,5 (53)	5,6 (22)	73,9 (393)
	Overweight	1,9 (1)	64,2 (34)	20,8 (11)	13,2 (7)	10,0 (53)
	Obese	0,0 (0)	25,0 (2)	62,5 (5)	12,5 (1)	1,5 (8)
	Total row % (n)	7,9 (42)	72,0 (383)	13,9 (74)	6,2 (33)	100,0 (532)

Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]

Table 3.10. Distribution in four weight classes at adolescence by preschool age in percentages and numbers for boys and girls separately and combined (All)

Weight class preschool age			Weight class adolescence: Thin % row (n)	Normal weight % row (n)	Overweight % row (n)	Obese % row (n)	Total % column (n)
	BOYS	Thin	23,8 (5)	71,4 (15)	4,8 (1)	0,0 (0)	7,5 (21)
		Normal weight	9,5 (22)	73,6 (170)	13,0 (30)	3,9 (9)	82,8 (231)
		Overweight	0,0 (0)	55,6 (10)	16,7 (3)	27,8 (5)	6,5 (18)
		Obese	0,0 (0)	0,0 (0)	33,3 (3)	66,7 (6)	3,2 (9)
		Total row % (n)	9,7 (27)	69,9 (195)	13,3 (37)	7,2 (20)	100,0 (279)
	GIRLS	Thin	18,5 (5)	77,8 (21)	3,7 (1)	0,0 (0)	10,7 (27)
		Normal weight	5,6 (10)	83,3 (150)	10,0 (18)	1,1 (2)	71,1 (180)
		Overweight	0,0 (0)	46,9 (15)	43,8 (14)	9,4 (3)	12,6 (32)
		Obese	0,0 (0)	14,3 (2)	28,6 (4)	57,1 (8)	5,5 (14)
		Total row % (n)	5,9 (15)	74,3 (188)	14,6 (37)	5,1 (13)	100,0 (253)
	ALL	Thin	20,8 (10)	75,0 (36)	4,2 (2)	0,0 (0)	9,0 (48)
		Normal weight	7,8 (32)	77,9 (320)	11,7 (48)	2,7 (11)	77,3 (411)
		Overweight	0,0 (0)	50,0 (25)	34,0 (17)	16,0 (8)	9,4 (50)
		Obese	0,0 (0)	8,7 (2)	30,4 (7)	60,9 (14)	4,3 (23)
		Total row % (n)	7,9 (42)	72,0 (383)	13,9 (74)	6,2 (33)	100,0 (532)

Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]

Overall a higher than expected proportion of children, 73 % remained in their weight class (thin, normal weight, overweight or obese) from 2-4 years of age to preschool age, compared to by chance alone, 59 % (given no tracking). Kappa statistics that compared the observed proportion of agreement with the proportion expected by chance, was overall K_w = 0,48 (boys: 0,45, girls: 0,51), considered a moderate to substantial agreement [60]. When looking specifically at the 53 children who were overweight at 2-4 years of age in Table 3.8, 53 % changed to normal weight class at preschool age, 32 % stayed overweight and 15 % gained weight and became obese. The group of obese children was small and interpretation was difficult. 5 of 8 stayed obese, 3 of 8 went down to overweight or normal weight.

A somewhat higher proportion than expected, 60 % kept their classification from 2-4 years of age to adolescence, compared to expected proportion if no tracking, 56 %. Weighted Kappa value was 0,22, (boys: 0,15, girls: 0,29) which was considered a fair to moderate agreement

[60]. From Table 3.9 we see that among the 53 kids who were overweight at 2-4 years of age, 64 % became normal weight or thin as adolescents, while only 21 % (24) stayed overweight and 13 % became obese. The obese group showed the same trend of more kids decreasing to overweight (5 of 8) or normal weight (2 of 8) than staying obese (1 of 8), over this longest time span investigated.

When looking at tracking from preschool age to adolescence, a higher proportion than expected, 68 % remained in their weight class, compared to as expected if no tracking was present, 58 %. Overall K_w = 0,48 (boys: 0,42, girls: 0,56), that was considered a moderate to substantial agreement [60]. From Table 3.10 we can see that among the 50 kids who were overweight at preschool age, 50 % were normal weight as adolescents, 34 % stayed overweight and 16 % gained weight and became obese. Among the 23 obese at preschool age, 61 % stayed obese, 30 % became overweight and 9 % decreased their weight to normal weight.

3.4.4 Estimation of tracking of OWOB by logistic regression analyses

In this model tracking was estimated by the odds ratio (OR) of being overweight/obese (OWOB) at measuring point II or III in relation to the weight classes thin/normal weight or OWOB at measuring point I or II. The model was adjusted for age at measuring point I or II, time between measuring points and sex. The same variables were tested for interaction and confounding. None of the variables were significant predictors, except sex at measuring point I till II. No significant confounders or interaction were found, so only crude OR is presented in Table 3.11. Separate analyses with only weight class in the model were done for boys and girls and crude OR is presented.

Table 3.11. Odds ratio and 95 % CI for being overweight/obese at preschool age or at adolescence in relation to the weight classes thin/normal weight or overweight/obese at 2-4 years of age or preschool age

Total n= 532		OWOB at preschool age		OWOB at adolescence	
	Weight class	Crude OR	95 % CI	Crude OR	95 % CI
2-4 years of age	Normal weight/thin	1,0		1,0	
	OWOB	11,6	6,4 - 21,0	3,0	1,7 – 5,3
	Boys n= 279				
	OWOB	7,9	3,0 – 20,5	2,1 [2]	0,9 – 5,2
	Girls n= 253				
	OWOB	13,8	6,2 – 30,5	4,1	1,9 – 8,6
Preschool age	Normal weight/thin	-	-	1,0	
	OWOB	-	-	11,1	6,4 – 19,2
	Boys n= 279				
	OWOB	-	-	9,0	3,9 – 21,1
	Girls n= 253				
	OWOB	-	-	15,1	7,1 – 32,0

Classification in weight classes are based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from 2012 [48]. OWOB = weight classes overweight/obese merged.
Model: Unadjusted OR of being overweight/obese (OWOB) at measuring point II or III in relation to the weight classes thin/normal weight or overweight/obese (OWOB) at measuring point I or II
The same model tested in separate analyses for boys and girls.
[2] Wald statistic p= 0,11

Tracking was present from both ages in childhood to adolescence as well as from 2-4 years of age to preschool age. Being overweight/obese as a child was a significant predictor of whether a person was being overweight/obese as adolescent. The odds of a 2-4 year old who was OWOB, for being OWOB as adolescent was 3 times higher (CI: 1,7-5,3) than those of a child who was normal weight/thin as 2-4 year old. The odds of a child who was OWOB at preschool age, being OWOB as adolescent, was 11 times higher (CI: 6,4-19,2) compared to a child who was normal weight/ thin at preschool age. Approximately the same result as from 2-4 years age to preschool age with an OR: 11,6 (CI: 6,4-21,0).

When we looked at boys and girls separately, tracking of OWOB was present for both sexes between all ages, but OR was higher for girls than for boys. The exception was boys 2-4 years old. Being OWOB as a 2-4 year old boy was not a significant predictor of being OWOB as adolescent, OR: 2,1 (CI: 0,9-5,2).

The results from the logistic regression analyses were in accordance with the results from the correlation analyses and the weighted Kappa analyses.

3.5 WC, WHtR and WHR as measurements of central overweight and obesity

Waist circumference (WC), waist to height ratio (WHtR) and waist to hip ratio (WHR) are supplements to BMI as measurements of central overweight and obesity. Table 3.12 shows gender specific data for WC, HC, WHtR and WHR at adolescence.

Table 3.12. Gender specific descriptive data for WC, HC, WHR and WHtR at adolescence

Total N= 532	Variables	Boys				Girls			
		Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
	Waist circumference (cm)	81,6[1]	11,82	60,5	128,5	76,6[1]	10,11	60,0	125,5
	Hip circumference (cm)	96,9	9,00	76,0	144,5	97,5	8,32	73,0	132,5
	Waist-hip ratio	0,84[1]	0,06	0,73	1,06	0,78[1]	0,06	0,68	1,23
	Waist-height ratio	0,46	0,07	0,36	0,72	0,46	0,06	0,37	0,75
	N	279				253			

[1] significant gender difference in means p< 0,001 using Mann-Whitney U test for comparing different groups.

In this material overall mean WC was 81,6 cm among boys and 76,6 cm among girls. WHtR was 0,46 among both boys and girls. WHR was 0,84 among boys, 0,78 among girls. There was a significant gender difference in WC and WHR, p < 0,001 using Mann-Whitney U test. The recommended cut-off point for WHtR is ≥ 0,5 for defining central obesity irrespective of gender and age [42,44,61]. 19,0 % (53) boys and 20,9 % (53) girls had a WHtR ≥ 0,5.

Internationally there is no well-accepted cut-off level for WC among children and adolescents for identifying central obesity [44,61]. New age and gender specific reference values for WC for Norwegian children 4-18 years were published in 2011 and the 85th and 95th percentiles of WC were proposed as cut-offs for central overweight and obesity [44]. We have compared our data for the 16 year olds to these suggested cut-off levels for 16,5 year old boys and girls.

Boys:	85th percentile (81,4 cm)	95th percentile (87,6 cm)	
	36,9 % (87)	22,9 % (54)	n= 236

Girls:	85th percentile (74,0 cm)	95th percentile (78,5 cm)	
	54,4 % (118)	32,7 % (71)	n= 217

The corresponding percentiles for WC for 16,5 year olds in our data material were:

	The 85th percentile	The 95th percentile
Boys:	92,5 cm	110,0 cm
Girls:	87,0 cm	98,5 cm

Suggested WC cut-offs for *adults* are divided in lower and upper level of need for action as associated with health risk/higher metabolic risk: Lower levels are 94 cm for men and 80 cm for women. Upper levels are 102 cm for men and 88 cm for women [62]. The prevalence rates of WC above these cut-off levels among all the adolescents 15-17 year old in our study were:

Boys:	WC ≥ 94 cm: 5,0 % (14)	WC ≥ 102 cm: 7,9 % (22)	n=279
Girls:	WC ≥ 80 cm: 16,2 % (41)	WC ≥ 88 cm: 12,6 % (32)	n=253

3.5.1 Correlation between WC, WHtR, WHR and BMI

There was a strong positive correlation between WC and BMI at adolescence: $r_s = 0,75$ (boys: 0,86 girls: 0,70) and WHtR and BMI: $r_s = 0,81$ (boys: 0,86 girls: 0,74). The correlation between WHR and BMI was positive, but moderate: $r_s = 0,37$ (boys: 0,53 girls: 0,28). All correlations were highly significant $p < 0,001$.

Correlations between BMI in childhood and WC and WHtR as adolescents were positive, but more moderate. Correlation coefficients for BMI at 2-4 years of age and WC at adolescence were $r_s = 0,30$. From preschool age to adolescent for the same variables $r_s = 0,45$. Correlation coefficients for BMI and WHtR at adolescence were: $r_s = 0,29$ and $r_s = 0,48$ from 2-4 years age and preschool age respectively. Correlation coefficients were generally a bit higher for boys than for girls.

4. Discussion

4.1 Findings

Our main findings according to the objectives will be summarised and discussed below.

4.1.1 Prevalence rates of overweight and obesity

The prevalence of OWOB increased with age. In childhood, the prevalence of OWOB was 8,6 - 9,7 % among boys and 14,6 - 18,1 % among girls. 1,4 - 3,2 % of the boys and 1,6 - 5,5 % of the girls were obese (OB). At adolescence 20,5 % of boys were OWOB and 7,2 % OB. 19,7 % of girls were OWOB and 5,1 % were OB.

This prevalence rate was comparable with those reported in other studies from Norway. Dvergsnes and Skeie found a prevalence rate of OWOB of 8,0-8,8 % and 14,6 -16,8 % among four year old boys and girls respectively from Tromsø, born in 1991 and 2001 [17]. The youths in Fit Futures were born in 1992-94. NIPH found in their studies from 2008 and 2010 a somewhat higher prevalence of OWOB (19 - 23 %) and OB (5 - 6 %) among 8-9 year old children from Health Region North [16]. Also Kokkvoll et.al found a higher prevalence of OWOB (16,2 % and 22,0 %) and OB (4,4 % and 5,8 %) among 6-year-old boys and girls respectively, born in Finnmark county in 1999-2000 [21]. Júliusson et.al. reported a prevalence of OWOB of 12,7 % in kids 2-5 years old, 17 % in the age group 6-11 years and 11,7 % in the age group 12-19 years. The corresponding figures for OB were 1,4 %, 3,6 % and 1,6 % (Bergen Growth Study) [19]. The prevalence rates in the younger kids in Bergen Growth study were comparable with ours, but the prevalence of OWOB among the adolescents in our study was almost twice as high. The prevalence of OB in our study was more than double than in Bergen Growth study. Differences in measuring method may affect the differences seen. The prevalence of overweight and obesity has increased in the period and the oldest youths in the Bergen Growth study were potentially born 10 years earlier than our youths. This may explain some of the difference in prevalence in this group, but probably not all. Another recent study from Norway found lower prevalence rates of OWOB among 6 year old children and 15 year old adolescents, than we did [51]. In The Young Hunt 3 study from 2006-08 the reported prevalence of OWOB was 27 % in boys and 25 % in girls (15-19 years) [24]. Height and weight were measured with the same method as in Fit Futures. This prevalence was higher than the prevalence of OWOB among the adolescents in our study.

Many studies have reported higher prevalence rates of OWOB from the northernmost part of Norway than the rest of the country [16,17,20–23]. Reported rates vary between 13 - 25 % both sexes combined. Figures for the whole country varies between 9 - 23 %. Highest figures have been reported for boys. These prevalence rates were obtained from self-reported data of height and weight, which might be underestimated [20,22,23]. Overall our findings are in accordance with prevalence rates reported in other studies for the northernmost region of Norway. The prevalence rates of OWOB among the adolescents in our study were higher than comparable rates for adolescents age 14-17 in most Nordic/ Western- Europe countries, but at the same level as for Southeast Europe and Britain [5].

The geographical differences (north-south within Norway) in prevalence rates have now been reported in several studies mentioned above. However, it is still not clear what factors that can explain these differences [20]. Some studies suggest that it is related to higher negative scores on health and lifestyle factors among adults in the northernmost counties and that this also applies for children and adolescents or a more obesogenic environment [5,21,22]. Rural – urban differences in OWOB has been reported from Norway [63]. This could be an explaining factor but needs to be investigated further. Tromsø is considered an urban area, but the municipality consists also of more rural parts.

4.1.2 Natural development of BMI and BMI SDS from childhood to adolescence

Mean BMI decreased from 2-4 years age to preschool measurements. This may be explained by the natural variation in BMI during early childhood and the adiposity rebound that occurs between 3-7 years, after a minimum in BMI. Mean BMI increased from childhood to adolescence, both as expected in a natural development [7,34,64,65]. No gender difference in mean BMI was found in any age group. BMI increased with 50 % among those OWOB at both preschool and at adolescence (10,56 kg/m^2 CI: 9,28-11,85) compared to a 30 % increase among those who were normal weight at both measuring points (5,48 kg/m^2 CI: 5,31-5,65).

Overall, BMI SDS increased significantly between all age levels. Among normal weight boys BMI SDS increased significantly from childhood to adolescence. Among normal weight girls BMI SDS were stable from childhood to adolescence. Among those overweight at both preschool and adolescence, BMI SDS stayed stable. This is in contrast to the larger increase in BMI in the same group. It has been suggested that short time change in adiposity in children are best evaluated by BMI and that BMI SDS are less suitable because it depends on baseline BMI [66], but BMI SDS are commonly used to look for more long term trends in growth [17,48,49]. Usually children with normal BMI development are expected to have a stable BMI SDS over time [35]. When BMI SDS is stable it indicates that the study sample, in this case the girls, followed the normal development in the reference population that the LMS curves are based on, in this case an international reference population [48]. A large increase in BMI SDS indicates that, in this case the boys, were gaining BMI more rapidly than expected and were at risk of becoming OWOB [35]. But it might also depend on difference in within-child variability between normal weight and overweight/obese children [66].

The different pattern of BMI SDS change may also be due to natural differences in growth and sexual maturation between girls and boys in Norway/ Northern Norway and compared to the international reference population. If a more detailed investigation of this should be done, it would be natural to calculate SDS according to background data for the Norwegian growth curves [64].

4.1.3 Tracking of overweight and obesity from childhood to adolescence

A positive result from this study was that the majority of the youths (≥ 80 %) stayed thin/normal weight between childhood and adolescence. However, we found indication of tracking of overweight/obesity (OWOB) from childhood to adolescence as well as from 2-4 years of age to preschool age. Being OWOB at preschool age increased the odds of being OWOB at adolescence, compared to normal/thin OR: 11,1 (CI: 6,4-19,2). The degree of tracking between OWOB at 2-4 years of age and OWOB at adolescence was weaker, OR: 3,0 (CI: 1,7-5,3) and not significant for boys. Weighted Kappa statistics gave a similar result with K_w ranging from 0,22 - 0,48 considered a moderate to substantial agreement. There was stronger degree of tracking among girls than boys. Results from the different tracking analyses were consistent.

As mentioned in the introduction, the fact that BMI and OWOB in childhood or adolescence tend to track into later in life is shown in many other studies [26–32,35,67]. It is difficult to compare results between studies because of the diversity in; age, time of follow-up, length of time intervals and analytic methods used [26]. A recent systematic review [26] concluded that reliable studies consistently reported increased risk of OWOB youths to become OWOB adults and that strong evidence was found that persistence of OWOB is moderate. The findings in this study are in line with this conclusion. A study from Iceland with participants born in 1988 and 1994, is most comparable with our study [28]. That study found that children who were OWOB at 2,5 years were more likely to be OWOB at age 6 (OR: 12,2) and 9 (OR: 4,9), but not significantly at later ages, than normal weight peers. OWOB children at 6 and 9 years of age were more likely (OR: 10,4 and OR: 18,6 respectively) to be OWOB at age 15 compared to their normal weight peers [28]. Our findings and OR are in accordance with the findings in this study. A comparable study from Sweden, following children from birth to 20 years of age found similar results, but somewhat lower OR. They found higher degree of tracking from 5,5 years to 20 years than from 2,5 years. Of the OWOB at 5,5 years, 60 % were OWOB at 20 years of age [67]. The magnitude of the tracking coefficient may be affected of inaccuracy of the BMI values and hence misclassification in weight class at childhood (discussed in paragraph 4.2.1). These figures must thus not be interpreted as absolute values. Different studies have reported varying predictive values [26]. Stronger degree of tracking for the obese group compared to the overweight group has also been reported [26,33,67]. In our study the obese group was to small to investigate this further.

Tracking were strongest between 2-4 years of age and preschool age (highest values of r_s and K_w). Both correlation and weighted kappa analyses are influenced by the time factor and interpretation must be done with caution [46]. In this study, there was different timespan between the three measuring points (I - II: 3,4 years, I - III: 14,0 years, II - III: 10,6 years). A higher correlation coefficient or Kappa value over short time isn't necessarily a stronger indication of tracking than a lower over a longer timespan [26,46]. The values of r_s and K_w were almost as high between preschool age and adolescence and may be considered as a stronger indication of tracking because the risk factor has been stable over a longer timespan. 63 % (6 out of 10) stayed OWOB between preschool and adolescence. In our study we didn't find a strong association between OWOB at 2-4 years of age and OWOB at adolescent. There was a higher percentage of change between weight classes over this period of time. This finding are also in accordance with the findings in the studies from Iceland and Sweden mentioned above [28,67]. Other studies have showed tracking of high BMI to later OWOB already from birth, 1 year of age or peak BMI in early infancy [5,34–36]. Some have suggested that it is the timing of the adiposity rebound that predicts later OWOB [65] others have found that having a high BMI at start, growing fast and upward centile crossing are risk factors for later OWOB [34]. This makes it difficult to conclude with certainty at the question of a critical age for OWOB development.

Although we found moderate to strong evidence of tracking of OWOB from childhood to adolescence, there was also a fairly high percentage of change between weight classes (13-23 %), and the proportion of OWOB children that became normal weight/thin were higher than the proportion of normal weight/thin that became OWOB (Table 3.5-3.7). Expressed in other words, not all OWOB adolescents were OWOB children and not all OWOB children become OWOB adolescents [26,67]. The finding is in accordance with the study from Sweden [67]. This shows the great opportunity to address the issue of preventing overweight and obesity at an early age. It also underlines the need for addressing both those at high risk as well as the general population of children and youths.

From a public health perspective, the positive finding was that the majority of children were normal weight and stayed normal weight up to adolescence. But children at high risk of becoming OWOB in later life can already be identified at preschool age. Other known risk factors than BMI alone must of course also be assessed to find the group at high risk [10]. In our study preschool age and primary school age stands out as a feasible time to focus on individual preventive efforts towards those at high risk. The preschool health control is already a natural meeting point between public health nurses, the children and their parents.

Others have pointed to the fact that school age is a better age to start preventive efforts than later ages [37,39]. Our study also showed that the prevalence of OWOB increased between childhood and adolescence and not all of those who became OWOB were OWOB in childhood. A broad focus on general preventive efforts therefore seems both important and appropriate. Broader preventive efforts towards the "obesogenic society" and all children are just as important. This also may prevent the strong stigmatic focus on the single obese child.

4.1.4 Gender differences

Based on BMI, more girls than boys were classified as OWOB in childhood. At adolescence this trend was turned around and more boys were classified as OWOB than girls. But the gender difference was only significant at preschool age. This is in accordance with findings from several other studies in Norway, for instance from the Bergen Growth Study [19], The NIPH study [16] and The Young HUNT study [24,68] and others [12,17,20–23]. We saw the same increasing trend in BMI SDS development among normal weight boys and from McNemar's test (paragraph 3.3 and 3.4.2). Among the adolescents, more girls than boys were classified as central overweight/obese based on WC and WHtR. This is the opposite of the proportion of OWOB based on BMI and is further discussed in the paragraph 4.1.5.

We found stronger degree of tracking among girls than boys, with higher values of correlation coefficients, OR and K_w among girls than boys between all age levels. Contrasting findings on this matter have been reported in other studies [26,28,33]. It is not clear what can explain this gender difference in prevalence rates of OWOB among young children, biological or environmental [18,19]. Several explanatory factors have been suggested for adolescents, like difference in sexual maturational status among adolescents, biological/genetic factors, difference in muscle mass [68,69] or factors related to body image [12,69]. In this project, we don't have data to further explain the gender differences that we have revealed.

4.1.5 WC, WHtR and prevalence of central obesity at adolescence

Measures of WC and WHtR showed higher mean values and indicate a higher proportion of adolescents with central overweight and obesity than comparable Norwegian studies. Compared to other Norwegian studies [44,51,52] mean WC differed with 5,6-8,4 cm in boys and 6,3-7,7 cm in girls with the highest values in our study. Mean WHtR in our study sample was 0,46 for both sexes. In the Bergen Growth Study [44] WHtR was 0,43 for boys and 0,41 for girls 16 year old. Our mean values are within the SD for some of the other studies, but difference is larger for the girls than the boys.

37 % and 23 % of boys, 54 % and 33 % of girls had a WC above the proposed Norwegian cut-off level at 85th and 95th percentile respectively, which should indicate central overweight or obesity. These are very high percentages of central overweight/obesity, especially among the girls. Some of the difference may be explained by difference in measuring methods of WC. Measuring method of WC in In Fit Futures, explained in paragraph 2.4.1, may give higher values of WC than measuring methods for WC used in the Norwegian reference cohort (WC measured on naked skin and at mid-point between the lowest rib and top of the iliac crest) [44]. It has been shown that difference in measuring methods can influence on the prevalence of subjects being identified at risk and makes it difficult to compare across studies [70]. However, it is not likely that the difference in measuring methods can explain all the difference in mean WC, WHtR and prevalence of central overweight/obesity. Mean BMI and weight was somewhat higher and height somewhat lower in our study sample compared to the Norwegian reference cohort in the Bergen Growth Study, which is said to be leaner than other comparable international study populations [44].

Even compared to the *adult* recommended cut-off levels [62], the proportion of adolescents with WC higher than these levels, were disturbingly high. More girls than boys were classified with central overweight/obesity. 5,0-7,9 % of the boys and 16,2-12,6 % of the girls had a WC ≥ the lower and upper action levels for adults respectively. Our findings thus indicate that WC and WHtR identify a higher proportion of individuals at risk, especially among girls, than weight class based on BMI. Hence, the simple public health message: "keep your waist circumference to less than half your height" [43] seems to an important message to be reminded about.

Other studies have found that difference in measuring method doesn't influence substantial on the association between WC and cardiovascular morbidity and mortality [70,71]. The high proportion of adolescents classified with central overweight/obesity based on WC give rise to concern. The finding needs to be further investigated in this cohort for instance with sensitivity and specificity calculations of WC and WHtR in according to results from DXA scans as gold standard for body composition. This is however outside the scope of this thesis. High correlation between WC and trunk fat measured by DXA scan has been showed in other studies [42]. We found relatively high positive correlation coefficients between WC and BMI r_s= 0,75 and WHtR and BMI r_s=0,81. 19,0 % of boys and 20,9 % of girls had a WHtR ≥ 0,5 which corresponds well with percentages of OWOB based on BMI (20,5 and 19,7 for boys and girls respectively). This indicates that it is fairly good agreement between the different measures of OWOB at adolescence and corresponds well with others findings [44]. Correlation between WHR and BMI at adolescence was more moderate r_s 0,37. This is in accordance with other studies and WC and WHtR are preferred measurements of central overweight and obesity in children and adolescents [42,44]. There are no recommended

Norwegian, or well accepted international, cut-off points for WHR in adolescents [11,44] and no further interpretation of this finding are thus done.

Correlation between BMI *in childhood* and WC and WHtR at adolescence was moderate and lower than correlation between BMI in both childhood and adolescence (paragraph 3.5.1 and 3.4.1). This underlines the need to validate the WC and WHtR measures as measurements of overweight/obesity and indicates that tracking revealed by BMI might be more moderate.

4.2 Methodological considerations

4.2.1 Study design, internal and external validity and reliability of the data

A retrospective cohort study design has the advantage that it is less costly and time consuming than prospective cohort study. We were therefore able to perform this master project within the time and financial limits of such projects. Longitudinal studies are most appropriate when it comes to tracking analyses [26]. The main limitation with our study design is the lack of standardization and monitoring of data collection of the childhood weight and height measurements.

Measurement bias [72](page 71), may be present due to uncertainty of the validity of the body height and bodyweight measurements in childhood. The measurements recorded in the childhood health record were measured as part of ordinary clinical visits to public health nurses and are not standardized measurements. Several factors can influence on the accuracy of height and weight measures, e.g. the accuracy and quality control of different weights and scales. Different nurses have performed the measures and inter-observer variability is likely to be present [72](page 106). Also factors with the children like if they were measured with or without clothes are an error source. In our study 34-43 % had height measures and 70-73 %

had weight measures with a decimal other than zero recorded in the health records at the two measuring points. This indicates that the measurements recorded in health records should be fairly correct. Usually these factors are anticipated to be non-differential errors that lead to both higher and lower height and weight measures that affect all weight classes in approximately equal amounts [17,21]. A recent published study from NIPH points to the fact that instrument errors due to lack of calibration of weights and scales leads to high variability in the data and systematically overestimate the prevalence of overweight and obesity [73]. It is difficult to estimate the magnitude of such instrument errors and other measurement errors in our data, so it is important to underline the uncertainty of the accuracy of the measurements collected from the childhood health records. Data collected in Fit Futures were standardized measures and a calibrated scale was used, [50] the data are therefore considered valid.

Quality control efforts were made to make sure that data collection in the master project was correct. Data entry was checked so no errors were introduced during this process. We consider the internal validity of the data to be acceptable.

Fit Futures 1 had a very high attendance rate of 93 % [40] compared to other epidemiological studies in youths, for instance “Young-HUNT II and III” (adolescents in high school) which has had an attendance rate of 78-79 % [74]. In Bergen Growth Study the attendance rate was 69 % in schools grade 1-7 (children) and 45 % in high school (adolescents) [44,64]. Initially selection bias should not be a problem in the Fit Futures cohort. The study sample with complete measurements used in this study, amount to 51 % of all participants in Fit Futures 1 and 55 % of the core group under 18 years. See Figure 2.1, page 9. Not included cases from the core age group had significantly higher values on main variables than the study sample used in this study, Table 2.1 (Appendix 1). We still consider the groups to be essentially the

same because the differences were small. However, it can be questioned if the study sample still is representative for the cohort and selection bias cannot be completely ruled out. This may affect the generalizability of the findings (external validity).
Prevalence rates of overweight and obesity have earlier been reported to be higher in the northernmost region of Norway, than in most other regions of the country [16,20,21,23], just like in our study. This must be taken into account and the prevalence rates for weight classes, WC, WHtR reported in this study are probably not representative for the whole country.

The number and choice of methods in the analyses may be questioned. The methods used in the tracking analyses are described as suitable and are used in other studies of tracking [28,45,46,75]. The use of logistic regression is considered suitable for analysing of tracking [46]. However, use of generalized estimating equations (GEE) would have been a more sophisticated method and a better approach than logistic regression. Among other factors it takes into account difference in time between measuring points and dependencies between repeated measures of the same individuals [45,46,56]. The GEE method is outside what we have learnt of statistical methods in the master program and was therefore not recommended by the supervisors. Other studies have used logistic regression in addition to GEE in tracking analyses and found similar results [56]. McNemar's test was done because it was used in the power-calculations. It has limitations, as it does not take into account the proportions that stay stable over two measuring points [72](page 185). Interpretation of the results is therefor done with caution and the results are not emphasized further. The use of several methods, which shows consistency between findings, is usually considered to strengthen the reliability of the findings [72](page 73).

The sample was not normally distributed for variables like BMI and BMI SDS. This is not unusual [5]. We used non-parametric tests that are considered to be more robust against not normally distributed data [50]. All results from the non-parametric tests were significant. This should account for the reliability of the test results.

4.2.2 Strengths and weaknesses

To the best of our knowledge, this is the only study reporting tracking of overweight and obesity between early childhood and adolescence in Norway/ North Norway. Tracking of overweight and obesity from childhood to adolescence and adulthood is shown in many studies from other countries and is a well-established and recognised fact [1,2,26]. However, it has not been shown to what extent this also was the situation in Norway /North Norway.

The high attendance rate in Fit Futures, a study sample with a comparable attendance rate as other Norwegian studies [64] and a fairly large sample of 532 subjects with three complete measurements in the tracking analyses [26], are considered as a strengths in this study. Despite this, the obese group was too small to investigate any differences between the obese group and the other weight classes separately. This is a weakness since other studies have indicated that degree of tracking is higher with more severe overweight and obesity [26,33].

A weakness with this study is the limited number of variables from childhood available and possible to collect. We don't have any explanatory variables from the same time as the childhood measurements. This gives us limited possibilities to explain our findings, except for what we know from other studies. Factors like differences between socio-economic groups, parent's educational level/ SES, parent's weight class, physical activity levels, sedentary time, eating habits or biological factors, are all factors that we do know from other studies

[12,19,22] to be associated with weight class and overweight/obesity, as described in paragraph 1.1.

4.3 Future studies

In this study the number of obese subjects was small and it was not possible to investigate differences between the obese group and other weight classes separately. Future studies should aim at collecting enough data to investigate this further.

We would recommend further investigation of the validity of the results for WC and WHtR and BMI compared to results from DXA scan, which has been performed in Fit Futures 1. A quality control of these measurements compared to results from DXA scans, as gold standard for body composition, is recommended. This is required confirm the accuracy of the prevalence rates presented in this master thesis.

Due to lack of explanatory variables, we have not been able to look into factors that can explain the findings in this study. It would be of interest to investigate some explanatory factors as mentioned in paragraph 1.1, for the adolescents in this cohort from Tromsø/ North Norway. Especially to see what factors that might explain the differences in prevalence rates of OWOB and central obesity among the adolescents revealed in this study compared to other study populations from Norway.

The follow-up study, Fit Futures 2, is now on-going. This provides opportunities to follow up on findings from this study.

5. Conclusion

- The prevalence of overweight/obesity increased with age from 8,6 - 9,7 % among boys and 14,6 – 18,1 % among girls in childhood to 20,5 % among boys and 19,7 % among girls at adolescence. Prevalence rates were in accordance with earlier findings reported for the northernmost region of Norway, and are generally higher than rates reported from other regions of Norway, with some exceptions.
- BMI decreased from 2-4 years to preschool age and increased to adolescence, following the natural change in BMI in childhood. Some differences in BMI and BMI SDS development were seen between normal weight and overweight/obese children.
- The majority of children stayed thin/normal weight from childhood to adolescence. We found moderate to strong indication of tracking of overweight/obesity, especially from preschool age to adolescence. 6 out of 10 children being overweight/obese at preschool age were overweight/obese also at adolescence. Tracking was strongest among girls. Tracking of overweight/obesity between 2-4 years of age and adolescence was weaker and not significant for boys. Many children also change their weight class during childhood. Not all overweight/obese adolescents were overweight/obese children and not all overweight/obese children become overweight/obese adolescents.
- Some gender differences were seen in prevalence of overweight/obesity and development in BMI SDS. No gender differences in BMI at any age.
- Among the adolescents, WC and WHtR identified a higher proportion with central overweight and obesity than comparable Norwegian studies, especially among girls.
- Preschool age and school age stands out as an important time for preventive efforts in that both tracking was present and prevalence of overweight/obesity increased from childhood to adolescence. Preventive efforts must therefore address both children at high risk and general prevention towards all children and the “obesogenic society”.

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Appendix 1. Tables

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Table 2.1. Descriptive data comparing available data from the core age group[†] with the study sample

		Not included cases		Study sample n= 532	
Variables		Mean values			
	Gender	Boys	Girls	Boys	Girls
Preschool age	Age	6,1	6,1 [1]	6,0	6,0 [1]
	Body height (cm)	119,1	117,9 [1]	117,8	116,1 [1]
	Body weight (kg)	22,2	22,1 *	22,0	21,6
	BMI kg/m^2	15,63	15,97 *	15,77	15,96
	BMI SDS	0,09	0,38 *	0,14	0,32
	N	50	40 (*n=38)	279	253
Adolescence	Age	16,1	16,2 [2]	16,0	16,1 [2]
	Body height (cm)	176,8	164,6 *	177,0	165,2
	Body weight (kg)	71,1	61,3 *	69,5	60,6
	BMI kg/m^2	22,69 [3]	22,60 [3] *	22,13 [3]	22,22 [3]
	BMI SDS	0,67 [5]	0,54 [4] *	0,49 [5]	0,40 [4]
	Waist circumference	82,6	78,0 *	81,6	76,6
	Hip circumference	98,3 [3]	98,0 *	96,9 [3]	97,5
	WHR	0,84	0,79 *	0,84	0,78
	WHtR	0,47	0,47 [6] *	0,46	0,46 [6]
	N	213	216 (*n=214/213)	279	253

All test are tested with Mann-Whitney U test, comparing means in 2 independent groups.
Monte Carlo sig. (2-tailed) 95 % CI reported.
[1] p=0,01
[2] p= 0,01
[3] p=0,03
[4] p=0,04
[5] p=0,04
[6] p=0,01

[†] The core age group in Fit Futures under 18 years old n= 961

Table 2.2. Classification in weight classes for the three age groups – comparison of old and new cut-off values

2-4 years of age

Weight class. Use of IOTF cut-offs from 2000-2007 [1]										
Gender	Boys					Girls				
Weight class	Thin	Normal	Overweight	Obese	Total	Thin	Normal	Overweight	Obese	Total
Number	38	218	20	3	279	31	185	33	4	253
%	13,6	78,1	7,2	1,1	100,0	12,3	73,1	13,0	1,6	100,0
Weight class. Use of new international cut-offs from 2012 [2]										
Gender	Boys					Girls				
Weight class	Thin	Normal	Overweight	Obese	Total	Thin	Normal	Overweight	Obese	Total
Number	41	214	20	4	279	37	179	33	4	253
%	14,7	76,7	7,2	1,4	100,0	14,6	70,8	13,0	1,6	100,0

Preschool age

Weight class. Use of IOTF cut-offs from 2000-2007 [1]										
Gender	Boys					Girls				
Weight class	Thin	Normal	Overweight	Obese	Total	Thin	Normal	Overweight	Obese	Total
Number	22	230	18	9	279	25	181	33	14	253
%	7,9	82,4	6,5	3,2	100,0	9,9	71,5	13,0	5,5	100,0
Weight class. Use of new international cut-offs from 2012 [2]										
Gender	Boys					Girls				
Weight class	Thin	Normal	Overweight	Obese	Total	Thin	Normal	Overweight	Obese	Total
Number	21	231	18	9	279	27	180	32	14	253
%	7,5	82,8	6,5	3,2	100,0	10,7	71,1	12,6	5,5	100,0

Adolescence

Weight class. Use of IOTF cut-offs from 2000-2007 [1]										
Gender	Boys					Girls				
Weight class	Thin	Normal	Overweight	Obese	Total	Thin	Normal	Overweight	Obese	Total
Number	27	195	37	20	279	17	186	37	13	253
%	9,7	69,9	13,3	7,2	100,0	6,7	73,5	14,6	5,1	100,0
Weight class. Use of new international cut-offs from 2012 [2]										
Gender	Boys					Girls				
Weight class	Thin	Normal	Overweight	Obese	Total	Thin	Normal	Overweight	Obese	Total
Number	27	195	37	20	279	15	188	37	13	253
%	9,7	69,9	13,3	7,2	100,0	5,9	74,3	14,6	5,1	100,0

Classification in weight classes is based on BMI, according to age and sex specific extended international (IOTF) cut-off values in children from [1] 2000/ 2007 or [2] 2012.

Table 3.13. Gender specific body height and body weight for the three age groups

2 - 4 years of age										
Age	Mean age	Body height in cm:				Body weight in kg:				
Years	(min-max)	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	n
Boys:										
2-3	2,6 (2,0-2,8)	92,7	3,7	83,0	102,0	14,1	1,6	10,4	22,0	265
3-4	3,2 (3,0-3,9)	98,9	3,1	93,0	104,0	15,1	1,6	13,0	19,0	14
Total:	2,6 (2,0-3,9)	93,0 [1]	3,9	83,0	104,0	14,1 [1]	1,6	10,4	22,0	279
Girls:										
2-3	2,5 (2,0-2,8)	91,0	3,4	81,0	100,5	13,4	1,5	9,9	19,0	239
3-4	3,1 (3,0-3,5)	94,9	4,2	88,0	103,0	14,9	1,6	11,5	17,8	14
Total:	2,6 (2,0-3,5)	91,3 [1]	3,5	81,0	103,0	13,5 [1]	1,6	9,9	19,0	253
Preschool age										
Age	Mean age	Body height in cm:				Body weight in kg:				
Years	(min-max)	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	n
Boys:										
4-6	5,7 (5,2-5,9)	115,9	4,9	101,0	126,0	21,0	2,9	15,7	35,7	123
6-7,5	6,3 (6,0-7,2)	119,4	4,7	108,5	135,0	22,7	3,9	17,5	38,5	156
Total:	6,0 (5,2-7,2)	117,8 [1]	5,1	101,0	135,0	22,0 [2]	3,6	15,7	38,5	279
Girls:										
4-6	5,7 (4,1-5,9)	114,2	4,9	100,5	132,0	20,8	3,7	15,0	39,0	129
6-7,5	6,3 (6,0-7,0)	118,0	4,5	108,0	128,0	22,5	4,2	16,2	38,1	124
Total:	6,0 (4,1-7,0)	116,1 [1]	5,0	100,5	132,0	21,6 [2]	4,0	15,0	39,0	253

Adolescence									
	Body height in cm:				Body weight in kg:				
Age	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	n
Boys									
15	173,5	6,3	161,7	183,4	64,2	10,0	53,6	87,9	17
16	177,2	6,4	159,6	194,9	70,1	15,3	43,6	136,5	236
17	177,1	8,6	162,6	196,6	67,0	11,5	47,8	98,7	26
Total: 16,0	177,0 [1]	6,6	159,6	196,6	69,5 [1]	14,8	43,6	136,5	279
Girls:									
15	166,4	4,5	162,7	175,9	57,5	8,8	46,3	73,3	8
16	165,0	6,5	146,5	187,1	60,9	12,2	39,8	114,1	217
17	166,3	5,6	156,4	178,2	59,0	9,8	45,1	88,5	28
Total: 16,1	165,2 [1]	6,4	146,5	187,1	60,6 [1]	11,8	39,8	114,1	253

All gender diff. tested with Mann-Whitney U test for comparing different groups.
[1] $p < 0.001$
[2] $p = 0.03$.

Table 3.14. Gender specific body mass index for the three age groups

2 - 4 years of age													
Boys:							Girls:						
Age		BMI					Age	BMI					Gender diff.
Years	Mean	Mean	SD	Min.	Max.	n	Mean	Mean	SD	Min.	Max.	n	p-value
2-3	2,6	16,37	1,33	12,72	22,45	265	2,5	16,17	1,38	12,91	20,62	239	
3-4	3,2	15,47	1,42	13,26	19,19	14	3,1	16,51	1,41	13,59	18,29	14	
Total:	2,6	16,33	1,35	12,72	22,45	279	2,6	16,19	1,38	12,91	20,62	253	0,25 [1]

Preschool age													
Boys:							Girls:						
Age		BMI					Age	BMI					Gender diff.
Years	Mean	Mean	SD	Min.	Max.	n	Mean	Mean	SD	Min.	Max.	n	p-value
4-6	5,7	15,63	1,42	13,63	22,85	123	5,7	15,84	1,94	12,78	25,42	129	
6-7,5	6,3	15,87	2,01	12,82	25,53	156	6,3	16,09	2,25	13,15	25,77	124	
Total:	6,0	15,77	1,77	12,82	25,53	279	6,0	15,96	2,10	12,78	25,77	253	0,51 [1]

Adolescence												
Boys:							Girls:					
Age		BMI					BMI					Gender diff.
Mean years		Mean	SD	Min.	Max.	n	Mean	SD	Min.	Max.	n	p-value
	15	21,38	3,79	17,86	33,62	17	20,86	3,74	17,16	27,69	8	
	16	22,28	4,44	16,05	42,87	236	22,39	4,25	16,19	41,16	217	
	17	21,30	2,91	16,48	30,53	26	21,32	3,23	17,46	29,08	28	
Total:	16,0	22,14	4,29	16,05	42,87	279	22,22	4,14	16,19	41,16	253	0,72 [1]

[1] All gender diff. tested with Mann-Whitney U test for comparing different groups.

Table 3.15. Gender specific BMI SDS[1] for the three age groups.

2 - 4 years of age													
Boys:							Girls:						
Age		BMI SDS					Age	BMI SDS					Gender diff.
Years	Mean	Mean	SD	Min.	Max.	n	Mean	Mean	SD	Min.	Max.	n	p-value
2-3	2,6	0,03	1,00	-3,39	3,63	265	2,5	0,06	1,00	-2,81	2,70	239	
3-4	3,2	- 0,39	1,13	-2,46	2,12	14	3,1	0,54	1,02	-1,79	1,70	14	
Total:	2,6	0,01	1,01	-3,39	3,63	279	2,6	0,08	1,00	-2,81	2,70	253	0,33 [2]

Preschool age													
Boys:							Girls:						
Age		BMI SDS					Age	BMI SDS					Gender diff.
Years	Mean	Mean	SD	Min.	Max.	n	Mean	Mean	SD	Min.	Max.	n	p-value
4-6	5,7	0,09	0,86	-1,51	3,46	123	5,7	0,28	1,07	-2,08	3,90	129	
6-7,5	6,3	0,18	1,01	-2,14	3,61	156	6,3	0,37	1,06	-1,54	3,56	124	
Total:	6,0	0,14	0,94	-2,14	3,61	279	6,0	0,33	1,06	-2,08	3,90	253	0,03 [2]

Adolescence												
Boys:							Girls:					
Age		BMI SDS					BMI SDS					Gender diff.
Mean		Mean	SD	Min.	Max.	n	Mean	SD	Min.	Max.	n	p-value
	15	0,50	0,93	-0,70	2,91	17	0,10	1,21	-1,24	1,95	8	
	16	0,52	1,14	-2,06	3,62	236	0,45	1,02	-2,05	3,36	217	
	17	0,14	1,00	-2,08	2,41	26	0,06	1,00	-1,46	2,07	28	
Total:	16	0,49	1,12	-2,08	3,62	279	0,40	1,03	-2,05	3,36	253	0,25 [2]

[1] BMI SDS was calculated using new revised LMS values from IOTF 2012 based on a international reference population of children.
[2] All gender diff. tested with Mann-Whitney U test for comparing different groups.

Table 3.16. Mean BMI SDS and adjusted BMI SDS and standard deviations for three different groups from childhood to adolescence

MEAN BMI SDS + ADJUSTED BMI SDS [1] (SD)						
ALL IN THE STUDY SAMPLE N= 532						
	All		Boys		Girls	
	Mean	Adjusted mean	Mean	Adjusted mean	Mean	Adjusted mean
2-4 years age	0.05 (1.01)	0.05 (0.61)	0.01 (1.01)	0.01 (0.63)	0.08 (1.00)	0.08 (0.58)
Preschool age	0.23 (1.01)	0.23 (0.42)	0.14 (0.94)	0.14 (0.41)	0.32 (1.06)	0.32 (0.42)
Adolescence	0.44 (1.07)	0.44 (0.63)	0.49 (1.12)	0.49 (0.67)	0.40 (1.03)	0.40 (0.57)
N	532		279		253	
SUBGROUP A - NORMAL WEIGHT AT ALL THREE AGES N= 263						
	All		Boys		Girls	
	Mean	Adjusted mean	Mean	Adjusted mean	Mean	Adjusted mean
2-4 years age	0.08 (0.55)	0.08 (0.39)	0.10 (0.60)	0.10 (0.41)	0.05 (0.48)	0.05 (0.35)
Preschool age	0.10 (0.52)	0.10 (0.32)	0.05 (0.50)	0.05 (0.31)	0.16 (0.53)	0.16 (0.32)
Adolescence	0.22 (0.59)	0.22 (0.42)	0.29 (0.60)	0.29 (0.43)	0.14 (0.57)	0.14 (0.40)
N	263		141		122	

SUBGROUP B - NORMAL WEIGHT OR OWOB AT BOTH PRESCHOOL AND ADOLESCENCE N=366				
	NORMAL WEIGHT		OWOB	
	Mean	Adjusted mean	Mean	Adjusted mean
Preschool age	0.08 (0.56)	0.08 (0.33)	2.25 (0.77)	2.25 (0.37)
Adolescence	0.22 (0.59)	0.22 (0.46)	2.29 (0.67)	2.29 (0.58)
N	320		46	

OWOB= Overweight/obese

[1] BMI SDS was calculated using new revised LMS values from IOTF 2012 based on a international reference population of children. Adjusted means are adjusted with an adjustment factor to eliminate between subjects difference to correct for repeated measures of the same individuals. The means are the same, but standard error and SD is smaller to get correct error bars.

Table 3.17. Mean BMI and adjusted BMI and standard deviations for two different groups from childhood to adolescence

MEAN BMI + ADJUSTED BMI (SD)				
ALL IN THE STUDY SAMPLE N= 532				
	Boys		Girls	
	Mean	Adjusted mean	Mean	Adjusted mean
2-4 years age	16.33 (1.35)	16.33 (1.71)	16.19 (1.38)	16.19 (1.65)
Preschool age	15.77 (1.77)	15.77 (1.06)	15.96 (2.10)	15.96 (1.00)
Adolescence	22.13 (4.29)	22.14 (2.46)	22.22 (4.14)	22.22 (2.21)
N	279		253	

SUBGROUP B - NORMAL WEIGHT OR OWOB AT BOTH PRESCHOOL AND ADOLESCENCE N=366				
	NORMAL WEIGHT		OWOB	
	Mean	Adjusted mean	Mean	Adjusted mean
Preschool age	15.44 (0.83)	15.44 (0.62)	20.22 (2.52)	20.22 (1.39)
Adolescence	20.92 (1.67)	20.92 (1.06)	30.79 (5.27)	30.78 (3.23)
N	320		46	

OWOB= Overweight/obese
Adjusted means are adjusted with an adjustment factor to eliminate between subjects difference to correct for repeated measures of the same individuals.
The means are the same, but standard error and SD is smaller to get correct error bars.

Appendix 2.

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Figure 1.1 BMI curves for girls and boys corresponding to the cut-off values for overweight and obesity (Coles index 2000)

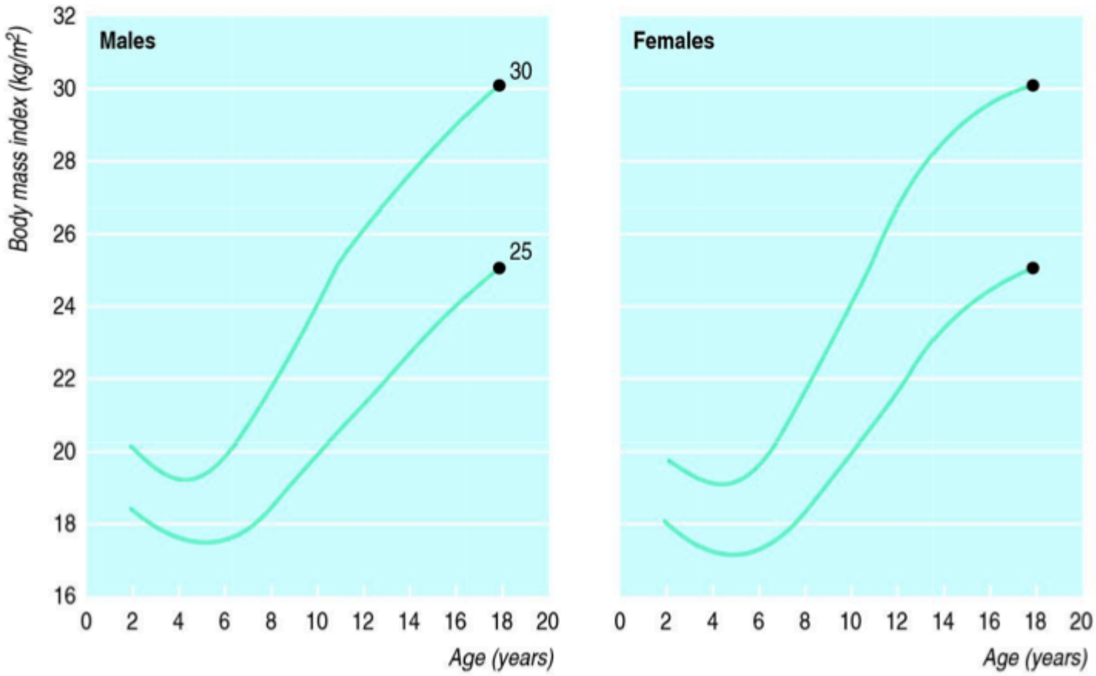


Figure 1.1. Shows BMI curves for the international cut-off points for overweight and obesity for boys and girls, passing through BMI at 25 and 30 kg/m^2 at 18 years (adults). Also named Coles index. The curves are based on international data of children from six countries (Brazil, Britain, Hong Kong, Netherlands, Singapore, and United States). Cole et.al. 2000 (7)

Figure 2.2 Histograms of Body mass index, gender specific for the study sample n= 532

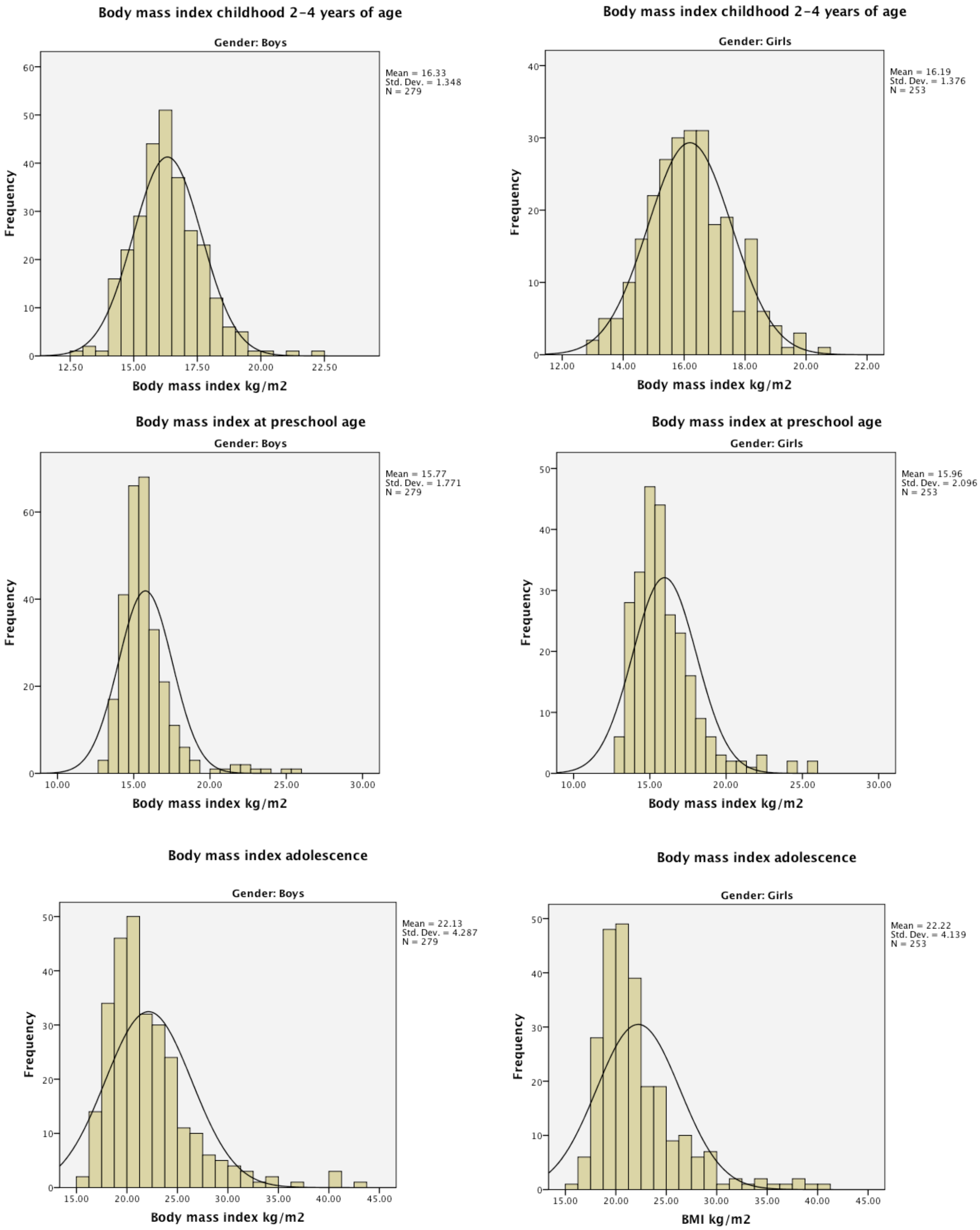
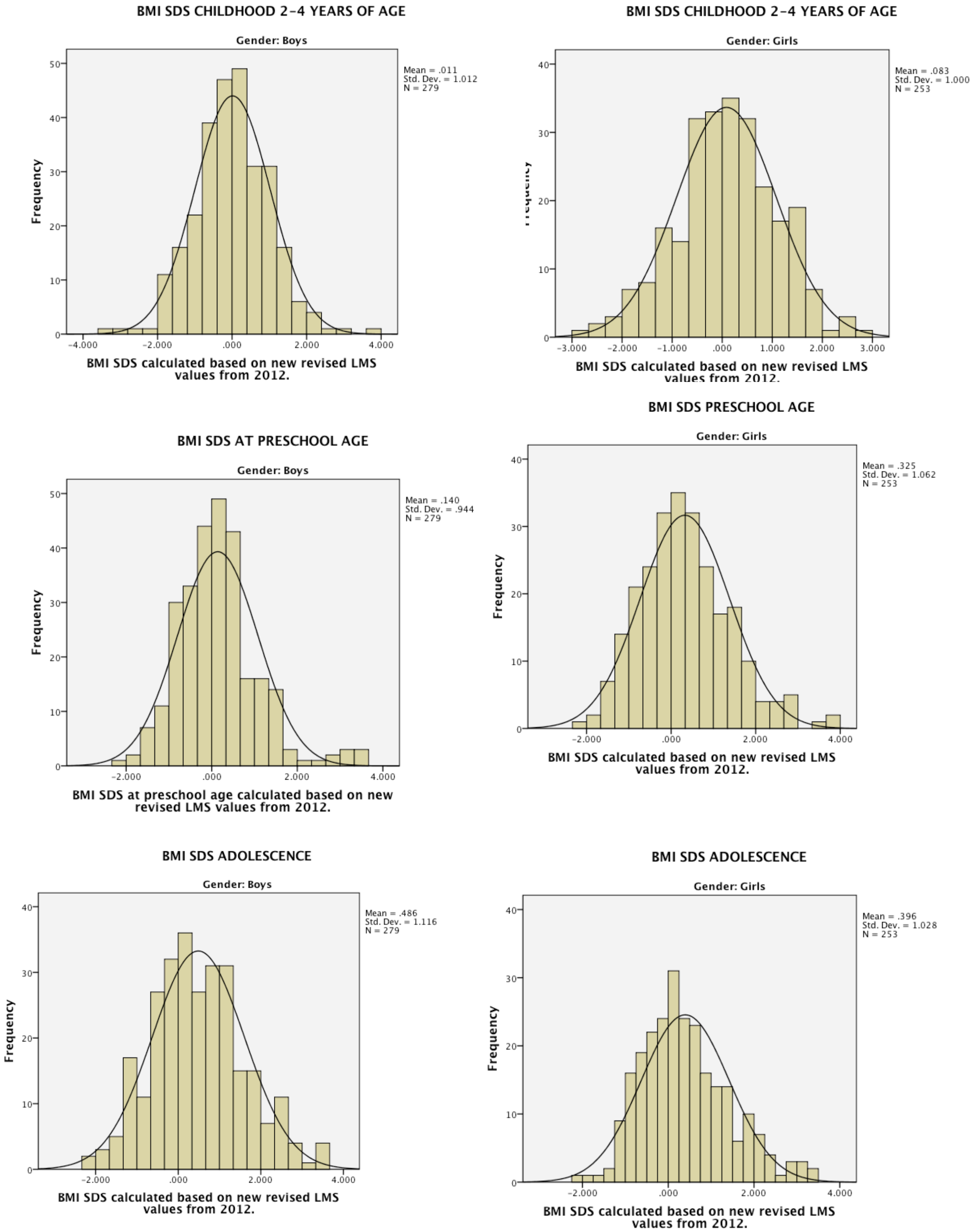


Figure 2.3 Histograms of BMI SDS, gender specific for the study sample n= 532



Appendix 3

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK nord			14.09.2011	2011/1284/REK nord
			Deres dato:	**Deres referanse:**
			15.06.2011	

Vår referanse må oppgis ved alle henvendelser

Guri Skeie
Universitetet i Tromsø

2011/1284 OMFANG OG STABILITET AV RISIKOFAKTORENE OVERVEKT OG FEDME I EN BARNE- OG UNGDOMSKOHORT

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk i møtet 25.08.2011.

Forskningsansvarlig: Bjørn Straume
Prosjektleder: Guri Skeie

Prosjektomtale (original):
Masteroppgaven er en del av delprosjektet Overvekt og fedme i Fit futures prosjektet, som igjen er en del av Tromsøundersøkelsen. Overvekt og fedme er et økende helseproblem på verdensbasis både blant voksne og barn, og betegnes av WHO som en global epidemi og som en av de viktigste trusler mot folkehelsa. Vi har generelt lite data om barn og unges vektutvikling i Norge. Vi vil samle inn høyde og vektdata fra helsestasjonsjournalen (ved 2/2,5 års alder og 5/6 års alder) for ungdommene som deltar i Fit futures. Dataene fra helsestasjonsjournalene vil kobles mot høyde, vekt innsamlet i Fit futures studien. Hensikten er å skaffe bedre data om forekomst av overvekt og fedme i en barne- og ungdomskohort, og se på i hvilken grad disse risikofaktorene er stabile fra førskolealder til videregåendeskolealder (tracking). Hensikten er også å beskrive en naturlig utvikling av kroppsmasseindeks - KMI fra førskole- til videregående skolealder. Masterprosjektet gjennomføres i perioden 2011-2012.

Forskningsetisk vurdering

Komiteen vurderer at prosjektet faller innenfor rammene av Fit futures og Tromsøundersøkelsen.

Komiteen har ingen merknader til prosjektsøknaden.

Komiteen har ingen merknader til informasjonsskriv og samtykkeerklæring.

Vedtak
Med hjemmel i helseforskningsloven § 10, jfr. forskingsetikkloven § 4 godkjenner komiteen at prosjektet gjennomføres i samsvar med det som framgår av søknaden.

Godkjenningen av prosjektet gjelder til 31.12.2012. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 31.12.2017. Opplysningene skal deretter slettes eller anonymiseres, senest innen 30.06.2018.

Opplysningene skal lagres avidentifisert, det vil si adskilt i en nøkkel- og en opplysningsfil.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder for «Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse- og omsorgssektoren».

Prosjektet skal sende sluttmelding til REK nord på fastsatt skjema senest 30.06.2013.

Tillatelsen er gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden og protokollen, og de bestemmelser som følger av helseforskningsloven med forskrifter.

Dersom det skal gjøres endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK. Vi gjør oppmerksom på at hvis endringene er "vesentlige", må prosjektleder sende ny søknad, eller REK kan pålegge at det sendes ny søknad.

Vi ber om at tilbakemeldinger til komiteen og prosjektendringer sendes inn på skjema via vår saksportal: http://helseforskning.etikkom.no. Øvrige henvendelser sendes på e-post til post@helseforskning.etikkom.no.

Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen,

May Britt Rossvoll
sekretariatsleder

Veronica Sørensen
førstekonsulent

Kopi til: postmottak@uit.no

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK nord	Veronica Sørensen	77620758	07.11.2012	2011/1284/REK nord
			Deres dato:	Deres referanse:
			02.11.2012	

Vår referanse må oppgis ved alle henvendelser

Guri Skeie
Universitetet i Tromsø

2011/1284 OMFANG OG STABILITET AV RISIKOFAKTORENE OVERVEKT OG FEDME I EN BARNE- OG UNGDOMSKOHORT

Forskningsansvarlig: Universitetet i Tromsø, Det helsevitenskapelige fakultet v/Bjørn Straume
Prosjektleder: Guri Skeie

Vi viser til søknad om prosjektendring datert 02.11.2012 for ovennevnte forskningsprosjekt. Søknaden er behandlet av leder for REK nord på fullmakt, med hjemmel i helseforskningsloven § 11.

Vurdering

Vi viser til skjema prosjektendring av 02.11.2012.

Endringene går ut på å forskyve sluttdato fra 2011 og frem til 31.12.2013.

Endringen begrunnes med at studenten av private grunner måtte forskyve på sluttdato for masteroppgaven og at det erfaringsmessig vil ta tid å få oppgaven publisert.

REK har i sin vurdering lagt vekt på at alle data allerede er samlet inn, slik at en utsatt sluttdato ikke vil få noen direkte betydning for deltagerne.

Dataene som analyseres er hentet fra Fit Futures og utleveres uten personidentifiserende kjennetegn eller koblingsnøkkel til prosjektet.

Etter fullmakt er det fattet slikt vedtak:

Vedtak
Med hjemmel i helseforskningsloven § 11 og forskningsetikkloven § 4 godkjennes prosjektendringen.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK nord. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK nord, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

May Britt Rossvoll
sekretariatsleder

Veronica Sørensen
rådgiver

Kopi til: *bjorn.straume@uit.no*

Datatilsynet

Universitetssykehuset i Nord-Norge
Avdeling for mikrobiologi og smittevern
V/ Furberg
9037 TROMSØ

Deres referanse	Vår referanse (bes oppgitt ved svar)	Dato
	07/00886-7 /CGN	27. juli 2010

Vedrørende søknad om utvidelse av konsesjon

Datatilsynet viser til Deres søknad av 27.04.2010 om utvidelse av konsesjon til å behandle helseopplysninger i forbindelse med Tromsøundersøkelsen I-VI.

Konsesjon til å behandle opplysninger i forbindelse med Tromsøundersøkelsen I-VI, ble forlenget i vedtak av 05.05.2010. Konsesjonen har varighet til 31.12.2011.

Søknaden om utvidelse omfatter en somatisk helseundersøkelse blant totalt ca 1100 elever på første trinn på videregående skole i Tromsø region 2010-2011, kalt *Fit futures*. Data fra Fit futures skal legges til å databasesystemet EUTRO (Epidemiologiske undersøkelser i Tromsø) ved Universitetet i Tromsø.

Metodene som skal benyttes i undersøkelsen, er spørreskjema og intervju med elevene, kliniske undersøkelser, laboratorieanalyser og kobling av registerdata.

Deltakelse i denne undersøkelsen skal baseres på samtykke. Deltakerne i studien er ungdommer på 15 og 16 år. I følge søknaden, skal det innhentes selvstendige samtykker fra de registrerte som har fylt 16 år, og fra de under 16 år skal det i tillegg innhentes samtykke fra deres foreldre.

Datatilsynet har vurdert søknaden og gir dem med hjemmel i helseregisterlovens § 5, jf. personopplysningslovens § 33, jf. § 34, utvidelse av konsesjon til å behandle helseopplysninger i forbindelse med helseundersøkelsen *Fit futures*. Utvidelsen er i samsvar med det omsøkte.

Utvidelsen medfører for øvrig ingen endringer i den opprinnelige konsesjonen med etterfølgende utvidelser.

Postadresse:	Kontoradresse:	Telefon:	Telefaks:	Org.nr:	Hjemmeside:
Postboks 8177 Dep 0034 OSLO	Tollbugt 3	22 39 69 00	22 42 23 50	974 761 467	www.datatilsynet.no

Dette vedtak kan påklages til Personvernnemnda i medhold av forvaltningslovens kapittel IV. Eventuell klage må sendes til Datatilsynet senest tre uker etter mottaket av dette brev.

Med hilsen

Monica Fornes
seniorrådgiver

Camilla Nervik
rådgiver

Kopi: NSD, Harald Hårfagresgate 29, 5007 Bergen

Appendix 4

PERSONVERN OG SIKKERHET

Alle medarbeidere som jobber med undersøkelsen, har taushetsplikt. Opplysningene som samles inn, vil bare bli brukt til godkjente forskningsformål, som beskrevet over.

Opplysningene og prøvene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger og prøver. Koden oppbevares separat ved Universitetet i Tromsø, og kun noen få autoriserte personer har tilgang. Den enkelte forsker får ikke tilgang til opplysninger som gjør det mulig å identifisere enkeltpersoner. Det vil ikke være mulig å identifisere deg i resultatene av studien når disse publiseres.

I noen tilfeller kan det være aktuelt å gjøre analyser av blodprøver eller genetiske analyser ved forskningsinstitusjoner i utlandet. Hvis dette gjøres, vil våre utenlandske samarbeidspartnere ikke få opplysninger som kan knytte prøvene opp mot deg som person.

Tromsøundersøkelsen gjennomfører Fit futures i samarbeid med Universitetssykehuset Nord-Norge og Nasjonalt folkehelseinstitutt. Data som samles inn på sykehuset, overføres til Universitetet i Tromsø når datainnsamlingen er avsluttet. Ingen av opplysningene som framkommer i undersøkelsen, lagres i journalsystemet på sykehuset. Databehandlingsansvarlig er Universitetet i Tromsø. Tromsøundersøkelsen administrerer utlevering av data til forskningsprosjekter. Hvem som er ansvarlig for forskningsprosjektene, finner du her http://www.tromsoundersokelsen.no. Fit futures er godkjent av Datatilsynet og Regional komité for medisinsk og helsefaglig forskningsetikk, Nord-Norge. Deltakere er forsikret gjennom Norsk Pasientskadeerstatningsordning.

FRIVILLIG DELTAKELSE

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i undersøkelsen, og dette vil ikke få noen konsekvenser for deg. Dersom du senere ønsker å trekke deg eller har spørsmål til studien, kan du kontakte Tromsøundersøkelsen, Institutt for samfunnsmedisin, Universitetet i Tromsø, 9037 Tromsø, telefon 77644816, e-post: tromsous@uit.no.

RETT TIL INNSYN OG SLETTING AV PRØVER OG OPPLYSNINGER OM DEG

Hvis du sier ja til å delta i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har også rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra studien, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

ENERGI

VIL DU DELTA?

Hvis du er fylt 16 år, gir du selv ditt samtykke til å delta. Du kan da signere vedlagte skjema (hvitt ark) og ta det med til undersøkelsen. Det er også mulig å undertegne skjemaet når du kommer til Forskningsposten.

Hvis du ikke er fylt 16 år, må du be dine foreldre/foresatte om lov til å delta. Da må både du og dine foreldre/foresatte signere vedlagte skjema (hvitt ark) som du tar med deg til undersøkelsen.

ANSVARLIGE FOR GJENNOMFØRING AV FIT FUTURES UNDERSØKELSEN

Fit futures ledes av en styringsgruppe, og følgende forskere er ansvarlige for gjennomføringen:

Anne-Sofie Furberg
prosjektleder, lege, Universitetssykehuset Nord-Norge
e-post: anne-sofie.furberg@unn.no, telefon 77 75 58 24

Christopher Sivert Nielsen
psykolog, Nasjonalt folkehelseinstitutt
e-post: Christopher.Sivert.Nielsen@fhi.no, telefon 21 07 82 77

Guri Grimnes
lege, Universitetssykehuset Nord-Norge og Universitetet i Tromsø
e-post: guri.grimnes@unn.no, telefon 77 66 94 83

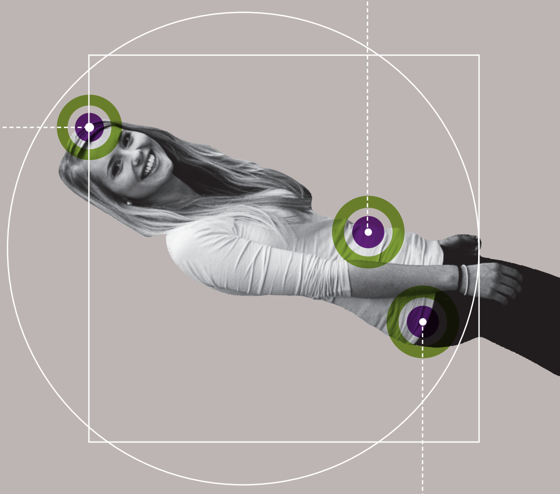
SPØRSMÅL?

Dersom du/dere har spørsmål om undersøkelsen, kontakt Forskningsposten UNN på telefon 77 62 69 09 eller prosjektadministrator for Fit futures på telefon 930 03 925.

www.fitfutures.no

UNN · VI BRYR OSS · SAMMEN TAR VI ANSVAR
UNIVERSITETET I TROMSØ
folkehelseinstituttet

FAST FOOD



SOSIALT NETTVERK

FitFutures
EN DEL AV TROMSØUNDERSØKELSEN

DIN HELSE DIN FREMTID

INVITASJON TIL Å DELTA I HELSEUNDERSØKELSE BLANT UNGDOM

HVA ER FIT FUTURES?

Fit futures er et forskningsprosjekt der vi undersøker ungdommers fysiske helse og livsstil.

HVORFOR ER DETTE VIKTIG?

Voksnes helse undersøkes i mange studier, men man har mindre kunnskap om helse blant ungdom. Selv om få ungdommer har alvorlige sykdommer, legges mye av grunnlaget for fremtidig helse i ungdomsårene. Denne undersøkelsen kan bidra til at vi får økt kunnskap om hvordan man kan forebygge sykdom og om hvordan diagnoser kan stilles på et tidligere tidspunkt.

HVA FORSKES DET PÅ?

Hovedområdene det forskes på er:

- Eksem og kviser
- Infeksjoner
- Fysisk aktivitet og overvekt
- D-vitamin
- Jernmangel
- Genmodifisert mat
- Miljøgifter
- Smerte
- Beintetthet
- Diabetes
- Øresus
- Medisinbruk
- Frafall fra skole
- Tannhelse

Informasjonen fra undersøkelsen vil også bli brukt til forskning om de store folkehelseproblemene generelt, slik som hjerte-karsykdommer, lungesykdommer, kreft, nedsatt fruktbarhet og smerte. Det vil også bli forsket på arbeidsførhet i skole og yrke i forhold til sykdom, helse og livsstil. En del av prosjektene vil studere samspillet mellom arv, miljø og sykdom og helse; til slike prosjekter vil det bli hentet ut genetisk arvestoff fra blodprøvene. I framtiden kan data bli brukt i forskningsprosjekter som i dag ikke er planlagt. For alle slike nye prosjekter kreves det at prosjektet er godkjent av Regional komité for medisinsk og helsefaglig forskningsetikk. En oversikt over godkjente prosjekter finner du her (www.tromsoundersokelsen.no). Nettsiden holdes løpende oppdatert. Her kan du også lese om våre forskningsresultater.

HVEM KAN DELTA?

Alle ungdommer på VG1 blir invitert til å delta. Hvis du er 16 år eller mer, kan du selv bestemme om du vil delta. Er du under 16 år, må du ha samtykke fra dine foreldre eller foresatte.

SLIK FOREGÅR UNDERSØKELSEN

Undersøkelsen gjennomføres i skoletiden. Selve undersøkelsen tar 2-3 timer, og du må påregne å være borte fra skolen en halv dag. Skolen anser dette som gyldig skolefravær. Du blir undersøkt på Forskningsposten, Universitetssykehuset Nord-Norge, av erfarne forskningssykepleiere og tannleger/tannhelsesekretærer. Undersøkelsen består av følgende deler:

- *Spørreskjema* der vi spør om livsstil, trivsel, sykdommer og helseplager gjennom livet, og familieforhold.
- *Intervju* der vi spør om hvilke medisiner du bruker, om du har noen sykdom i dag og litt om sosialt nettverk. Kvinner spørres også om menstruasjon og graviditet.
- *Generell helseundersøkelse* der vi måler høyde, vekt, livvidde og hoftevidde, blodtrykk og puls, samt tar blodprøve, en hårprøve fra nakken, og en bakterieprøve fra nesebor og hals med en fuktet vattpinne.
- Måling av *smertefølsomhet* der vi måler følsomhet for trykk, kulde og varme. Smerten kommer gradvis, og du kan selv avbryte når som helst.
- *Kroppsscan* (DEXA) der vi måler beintetthet og forholdet mellom fett- og muskelvev. Dette skjer ved at du ligger rolig i ca. 10 minutter mens kroppen scannes.
- *Tannundersøkelse* som blir din årlige undersøkelse ved den offentlige tannhelsetjenesten og omfatter klinisk undersøkelse, tannrøntgen, kliniske foto og avtrykk for studiemodeller.

Etter undersøkelsen vil du få utlevert en liten *aktivitetsmåler* som er festet i et smalt strikkbelte til å ha under klærne. Denne måler hvor mye du beveger deg i løpet av dagen. Apparatet leveres på skolen etter en ukes bruk. Da vil det samtidig tas ny bakterieprøve fra nesebor og hals.

Noen deltakere vil bli forespurt om å undersøkes en gang til. Det vil da være aktuelt å gjenta noen av undersøkelsene og gjøre enkelte utvidede undersøkelser.

HVA SKJER MED DE BIOLOGISKE PRØVENE?

Med blodprøven gjøres analyser av bl.a. hormonnivåer, fettstoffer, blodsukker, vitaminer, miljøgifter og markører på betennelse og sykdommer. Det blir også hentet ut arvestoff (DNA og RNA) for genetiske analyser. Bakterieprøvene brukes til å måle forekomst av gule stafylokokker. Hårprøven analyseres for å se på nivå av kvikksølv. Prøvene lagres i Forskningsbiobanken for Tromsøundersøkelsen ved Universitetet i Tromsø. Hvis du sier ja til å delta, gir du også samtykke til at de biologiske prøvene og analyseresultatene inngår i biobanken.

INFORMASJON FRA ANDRE KILDER OG BRUK AV DATA I FRAMTIDEN

Opplysninger og prøver som du gir, blir oppbevart på ubestemt tid til bruk i forskning omkring helse og sykdom som omtalt i denne brosjyren. Det kan også hende at vi tar kontakt med deg igjen for å spørre om du vil være med på en ny undersøkelse. For spesielle forskningsprosjekter kan det være aktuelt å sammenstille informasjon fra Fit futures med nasjonale helseregistre som Reseptregisteret, Medisinsk fødselsregistrer, Kreftregisteret, Norsk pasientregister, Dødsårsaksregisteret og andre nasjonale registre over sykdommer som det forskes på i Tromsøundersøkelsen. I tillegg kan det være aktuelt å innhente helseopplysninger fra spesialist- og primærhelsetjenesten, for eksempel informasjon om beinbrudd og høyde- og vektdata fra helsestasjon, til bruk i forskning på sykdommer og helseproblemer som det forskes på i Tromsøundersøkelsen. Det kan også bli innehentet data fra registre i Statistisk sentralbyrå slik som miljø, befolkning, utdanning, inntekt, offentlige ytelser, arbeidsdeltakelse og andre forhold som kan ha betydning for helsa. For å undersøke om sykdommer går i arv, kan opplysninger om deg sammenstilles med opplysninger om dine slektninger, dersom disse har deltatt i deler av Tromsøundersøkelsen. Dette blir gjort ved å innhente opplysninger om slektskap fra Familieregisteret. Fra skolen vil vi innhente dine opplysninger om studieprogram, klasse, kjønn, antall fraværsdager, om du fullfører skoleåret og om karakterer i fagene norsk, matematikk og engelsk.

Sammenstillinger av informasjon krever noen ganger nytt samtykke og/eller annen type godkjenning slik som dispensasjon fra taushetsplikten eller godkjenning av offentlige instanser, for eksempel Regional komité for medisinsk og helsefaglig forskningsetikk, Datatilsynet eller NAV.

MULIGE ULEMPER OG FORDELER

Deltakelse innebærer at du må bruke noe tid. Deler av undersøkelsen kan også innebære ubehag. Dette gjelder særlig blodprøven. Dersom du vet at du har problemer med å ta blodprøve, kan du kontakte Forskningsposten på telefon 77 62 69 09 eller snakke med sykepleier når du kommer til undersøkelsen for å finne en løsning på dette.

Dersom resultatet av prøvene dine viser at det er nødvendig med oppfølging av tannlege, lege eller henvisning til spesialist, vil du bli orientert om det. Ved behov for henvisning til spesialist, vil vi sørge for henvisning og tilbud om oppfølging ved sykehuset.

Deltakere får et gavekort til en verdi av kr. 200 ved oppmøte som kan brukes i de fleste butikker i Tromsø.

TEKNOLOGI

SMERTE

FitFutures
EN DEL AV TROMSØUNDERSØKELSEN

VIL DU DELTA?

Samtykke til å delta i studien Fit futures

Jeg er villig til å delta i studien

____

(DITT FULLE NAVN I BLOKKBOKSTAVER)

Sted ____________________ Dato ____________________

____

(DIN SIGNATUR)

VIL DU DELTA OG ER UNDER 16 ÅR?

Foreldre/foresatte sitt samtykke til deltakelse i Fit futures

Jeg samtykker herved i at mitt/vårt barn kan delta i undersøkelsen

____

(BARNETS FULLE NAVN I BLOKKBOKSTAVER)

Sted ____________________ Dato ____________________

____

(SIGNATUR FORELDER/FORESATT 1)

____

(SIGNATUR FORELDER/FORESATT 2)