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Conflict of interest

All the authors declare that there are no conflicts of interest.

Abstract

Introduction

This study aims to evaluate a potential selection effect caused by exclusion of children with non-identifiable infancy peak (IP) and adiposity rebound (AR) when estimating associations between age and BMI at IP and AR and later weight status.

Subjects and Methods

In 4 744 children with at least 4 repeated measurements of height and weight in the age interval from 0 to 8 years (37 998 measurements) participating in the IDEFICS/I.Family cohort study, fractional polynomial multi-level models were used to derive individual BMI trajectories. Based on these trajectories, age and BMI at IP and AR, BMI values and growth velocities at selected ages as well as the area under the BMI curve were estimated. The BMI growth measures were standardized and related to later BMI z-scores (mean age at outcome assessment: 9.2 years).

Results

Age and BMI at IP and AR were not identifiable in 5.4% and 7.8% of the children, respectively. These groups of children showed a significantly higher BMI growth during infancy and childhood. In the remaining sample, BMI at IP correlated almost perfectly ($r \geq 0.99$) with BMI at ages 0.5, 1 and 1.5 years whereas BMI at AR correlated perfectly with BMI at ages 4 to 6 ($r \geq 0.98$). In the total study group, BMI values in infancy and childhood were positively associated with later BMI z-scores where associations increased with age. Associations between BMI velocities and later BMI z-scores were largest at ages 5 and 6. Results differed for children with non-identifiable IP and AR demonstrating a selection effect.

Conclusions

IP and AR may not be estimable in children with higher-than-average BMI growth. Excluding these children from analyses may result in a selection bias that distorts effect estimates. BMI values at age 1 and age 5 might be more appropriate to use as predictors for later weight status instead.

Word count: 300/300

Introduction

The obesity epidemic is of growing concern, especially in children[1, 2]. Lots of research has been conducted to identify early life factors and weight, height or body mass index (BMI) growth characteristics in infancy and childhood related to an unfavorable weight development[3-11]. For instance, a late age at infancy peak (IP), an early age at adiposity rebound (AR) as well as BMI at IP and AR were shown to be positively associated with later adiposity status[12-19]. The IP describes the maximum of a BMI growth curve occurring at an age of about 9 months, whereas the AR denotes the nadir at an age of about 6 years that occurs before the BMI curve increases once again. However, the BMI is just a function of weight (kg) divided by height (m) squared such that the minimum and maximum of a BMI trajectory may not have a biological meaning. From a public health perspective, the usefulness of these measures has also been questioned because age and BMI (in the following: age/BMI) at infancy peak and adiposity rebound can only be determined retrospectively. Hence, the potential use for intervention purposes is limited. Dietz suggested the AR to be mainly an epiphenomenon[20]. As discussed by Cole[13], early AR may be a risk factor for later obesity only as it identifies children whose BMI centile is high and/or crossing upwards. Also rapid growth[3] and catch-up growth[21] predict later obesity status and may be strongly related to age/BMI at IP and AR. These measures provide more direct indicators of later obesity risk and amongst others biological programming of obesity during fetal and early postnatal life has been suggested as an underlying mechanism[21-24].

BMI growth characteristics are typically determined based on growth curve modeling because approaches based on visual inspection are not feasible in large cohort studies with a limited number of repeated BMI measurements[25, 26]. Fractional polynomial multi-level models (FPMLM) provide a flexible tool for this purpose as these models can handle unbalanced data, i.e. a varying number of measurements per individual at irregular time points, under a missing at random assumption[26, 27]. The improvement of multi-level models over conventional general linear regression for estimating growth curves has been demonstrated by Johnson et al.[28].

However, there is an additional problem with the use of the IP and AR as exposures. The IP and AR are not always identifiable, e.g. as observed by Wen et al.: “this occurs when the individual-specific curves lack a local maximum (infancy peak) or minimum (adiposity rebound)”[26]. Typically, children with non-identifiable IP or AR are excluded from the subsequent analysis. But not observing a minimum or maximum could be a result of a BMI trajectory that is continuously increasing during infancy and childhood. This might especially be likely in overweight/obese children. Exclusion of children with non-identifiable IP or AR could thus result in under-representation of overweight children, a bias that may also affect effect estimates of later disease risk.

The present study aims to investigate the usefulness of the IP and AR in comparison to other measures of BMI growth as indicators of later weight status. For the first time, the selection effect possibly occurring when excluding children with non-identifiable IP or AR will be explored. For this purpose, associations between various BMI growth measures and later weight status will be estimated based on a sample of European children from a multi-center cohort study.

Subjects and methods

Description of the study population

The IDEFICS (Identification and Prevention of Dietary- and Lifestyle-Induced Health Effects in Children and Infants) cohort is a multi-center population-based study

aiming to investigate the causes of diet- and lifestyle-related diseases in 2.0 to 9.9 year old children. The baseline survey (T0) was conducted from September 2007 to May 2008 in eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Sweden, Spain) where 16 228 children participated. Children were approached via schools and kindergartens to facilitate equal enrolment of all social groups. The survey included interviews with parents concerning lifestyle habits and dietary intakes as well as anthropometric measurements and examinations of the children. All measurements were taken using standardized procedures in all eight countries. Details on the design and objectives of the study can be found in Ahrens et al.[29-31]. A first follow-up examination (T1) was conducted in 2009/2010 applying the same standardized assessments where 13 596 children aged 4.0-11.9 years were enrolled (2 555 newcomers; 11 041 children who participated already in T0). A second follow-up examination (T3[*]; I.Family) took place in 2013/2014 during which 7 105 out of the children already participating at T0 or T1 were examined.
Parents and children aged 12 years and over gave written informed consent while younger children gave oral consent prior to the examinations. Each study center obtained ethical approval by the local institutional review board.

Anthropometric measurements

Height [cm] of the children was measured to the nearest 0.1 cm with a calibrated stadiometer (Seca 225 stadiometer, Birmingham, UK), body weight [kg] was measured in fasting state in light underwear on a calibrated scale accurate to 0.1 kg (adapted Tanita BC 420 MA for children ≤6 years, BC 418 MA for children >6 years,

[*] In 2010/2011, an additional postal survey was conducted (T2). As no physical examinations took place, the T2 data are not considered here.

Tanita Europe GmbH, Sindelfingen, Germany). BMI was calculated as weight [kg] divided by height [m] squared. The BMI at last follow-up examination was converted to an age- and sex-specific z-score using the extended criteria of the International Obesity Task Force (IOTF)[32]. Apart from the heights and weights measured at the T0, T1 and T3, additional height/weight measurements from records of routine child visits or registry data (part of birth data in Sweden) were collected in Belgium, Cyprus, Germany, Hungary, Italy, Spain and Sweden and linked to the survey data (up to 33 measurements per child). Information was supplemented by parentally reported birth weights and lengths (questionnaire data) if measurements of birth length/weight were missing in the records of routine child visits. Good repeatability was previously shown for maternally reported birth characteristics and pregnancy-related events in IDEFICS[33]. Good agreement was also observed between measured and reported birth lengths and weights (unpublished data).

Analysis dataset

The flow chart in Fig 1 visualizes the numbers of height and weight measurements available from the different sources and summarizes the exclusion process leading to the final analysis dataset.

(Please insert Fig 1 here)

Because data from records of routine child visits were not available from Estonia, only seven countries were included in the analysis. In total, 75 787 height/weight measurements of 14 509 children were available with numbers of measurements as well as time points of measurements varying among children. As described in detail elsewhere[34], duplicate observations (30 obs), implausible height/weight measurements or combinations (4 131 obs), heights decreasing by more than 20%

(38 obs) as well as weights decreasing by more than 50% (14 obs) over time were excluded. To achieve sufficient model stability, only measurements in the age interval from 0 to 8 years were considered as well as only children with a minimum of four repeated measurements (45 417 observations of 5 026 children). To account for collinearity of measurements taken closely in time, a minimum time lag of 1 month (for measurements taken below 6 months of age), 2 months (measurements between 6 months to 1.5 years) or 3 months (measurements > 1.5 years), respectively, was imposed by random deletion of 6 353 measurements taken closer in time. Other inclusion criteria were that for each child at least one measurement should lie in the potential age range of the IP (>0.25 to ≤4 years) and of the AR (>2.5 to ≤8 years), and that information on birth term (pre-term vs. in time) was available. The final analysis group consisted of 4 744 children with 37 998 height and weight measurements. The average number of repeated measurements per child was 8 (median: 8, interquartile range: 6-9); numbers of BMI measurements by age group and sex are given in Table S1 as supplementary material. Comparing the final analysis sample with the original IDEFICS cohort, distributions of sex and weight status were almost identical.

Statistical analysis

Growth trajectories were modelled using fractional polynomial multi-level models with two levels (measurement occasion and individual) allowing individuals to have different intercepts and age-effects, i.e. their own trajectory[27]. As described previously[34], in a first step all fractional polynomials with up to three powers of age out of the following powers (-2, -1, -0.5, log, square root, 1, 2, 3) were estimated to identify the best-fitting model for BMI growth. As age must be strictly positive when using fractional polynomials[35], this was achieved by adding a constant of 0.001 to age at birth. The best-fitting fractional polynomial according to both, the Bayesian information criterion (BIC; value: 108709) as well as the Akaike information criterion (AIC; value: 108576), reads as follows:

$$BMI_{i,j} = \left(\beta_0 + u_{i,0} + \varepsilon_{i,j}\right) + \left(\beta_1 + u_{i,1}\right) age_{i,j}^{1} + \left(\beta_2 + u_{i,2}\right) age_{i,j}^{2} + (\beta_3 + u_{i,3}) \log\left(age_{i,j}\right)$$

where $\beta_0, \beta_1, \beta_2, \beta_3$ denote the fixed intercept and slopes, $u_{i,0}, u_{i,1}, u_{i,2}, u_{i,3}$ denote the random intercept and slopes and $\varepsilon_{i,j}$ denotes the error term with $i=1,\ldots n$ and $j=1,\ldots n_i$ (n: number of subjects; n_i: number of measurements of subject i).

Using SAS PROC MIXED the BMI growth model was estimated adjusting for sex and birth term (born in time vs. pre-term) including respective interactions with the age terms, as well as for measured vs. reported BMI at birth to adjust for differential measurement error.

Based on the estimated individual BMI trajectories, 29 measures of BMI growth were derived as described in Wen et al.[26]: age at IP and AR, BMI at IP and AR, BMI values and growth velocities (kg/m^2/year) at defined ages (0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 6, 7 and 8 years) and cumulated BMI growth measures (area under the curve (AUC): birth to 2 years, birth to 5 years, birth to 8 years).

Applying the classifications most commonly used in previous studies, age at IP was categorized into ‘Early: age at IP < 8 months’, ‘Medium: 8 months ≤ age at IP < 1.0 years’, ‘Late: age at IP ≥ 1.0 years’ and ‘Not estimable’. Analogously, age at AR was categorized as ‘Early: age at AR < 5 years’, ‘Medium: 5 ≤ age at AR < 7 years’, ‘Late: age at IP ≥ 7 years’ and ‘Not estimable’.

For each IP and AR category, pairwise Pearson correlation coefficients between the derived BMI growth measures were calculated. In addition, associations between the BMI growth measures and later BMI z-score (last available BMI measurement; mean age: 9.2 years) were estimated using linear regression models adjusting for sex and study center. For this purpose, the BMI growth measures were standardized to allow direct comparability of the effect estimates. All models were estimated for the whole study group, for children with non-estimable vs. estimable IP as well as for children with non-estimable vs. estimable AR to assess possible differences in effect estimates between these groups, i.e. to assess a potential selection effect when ignoring children with non-identifiable IP or AR. Effect estimates were compared based on (non-)overlapping 95% confidence intervals.

All analyses were performed using SAS® statistical software version 9.3 (SAS Institute, Inc., Cary, NC).

Results

The average age at IP was 0.9 and age at AR 5.2 years. The IP or AR were not identifiable in 5.4% (N=257) and 7.8% (N=371) of the children, respectively. Table 1 displays distributions of sex, weight status at last follow-up and birth term (born in time vs. pre-term) by IP and AR categories (early, medium, late, not estimable). As expected, percentages of overweight/obese children were higher in the groups of children with late IP (30.6%) and early AR (33.0%) compared to children in the other IP and AR categories and compared to the total study group (18.2%). Even more of the children with non-estimable IP or AR, 76.2% and 55.2%, respectively, were classified as overweight/obese.

From an age of 1.5 years onwards, BMI values of children with non-estimable IP and AR were significantly higher than average BMI values in the total group (see Table 2 and Figure 2). Also BMI growth velocities were higher at all ages in the groups of children with non-estimable IP and AR compared to the total study group.

As displayed in Table 3, BMI at IP showed almost perfect correlation with BMI values at ages 0.5, 1, and 1.5 years and very high correlations (r>0.9) with BMI up to age 3. BMI at AR showed the highest correlation with BMI at age 5 (r=0.99) and very high correlations with BMI at ages 3 to 7 (r>0.9). Both, BMI at IP and AR were most strongly correlated with BMI growth velocities in early infancy. Age and BMI at AR were also strongly positively correlated with the AUC measures; correlations of age and BMI at IP with the AUC were moderate to low.

(Please insert Fig 2 here)

Table 4 presents the results of the regression models relating the standardized BMI growth measures to later BMI z-scores for children with estimable vs. non-estimable IP and AR as well as for the total study group. For children with estimable IP or AR, in addition associations between standardized BMI/age at IP/AR and later BMI z-score are displayed. At all ages and in all subgroups, standardized BMI values, velocities and the AUC measures were positively associated with later BMI z-score. With regard to BMI values, associations increased from infancy to childhood and were largest for BMI at age 7 and 8. BMI velocities at age 5 and 6 showed the strongest association with later BMI z-score; in children with non-estimable IP or AR associations were stronger at younger ages. For AUC measures, associations were largest when accumulating BMI values from birth to 8 years in all groups. Later BMI z-score was similarly associated with (a) BMI at IP and BMI at age 1, and (b) BMI at AR and BMI at age 3 and 4 years. Effect estimates for BMI values, velocities and AUC measures with later BMI z-score were in general markedly smaller in the group of children with non-estimable IP compared to the total study group. From an age of

5 years onwards, associations between BMI values in childhood and later BMI z-score were significantly higher in children with identifiable IP and AR compared to the total study group demonstrating a distortion of effect estimates caused by a selection effect. In general, later BMI z-score in children with an identifiable IP was significantly smaller (1.54 SD) compared to children with non-identifiable IP. Analogously, later BMI z-score in children with an identifiable AR was significantly smaller (0.86 SD) compared to children with a non-identifiable AR.

Discussion

This is the first study documenting the selection effect that occurs – as is usually done – if children with non-identifiable IP or AR are excluded when estimating associations of age and BMI at IP/AR with later weight status. In this context, the usefulness of age and BMI at IP and AR in comparison to other BMI growth measures as predictors for later weight status has also been evaluated.

Consistent with the literature[15-18, 20], in the present study age and BMI at IP as well as BMI at AR were found to be positively associated and age at AR was negatively associated with later BMI z-score. In our sample, age/BMI at IP and AR were not identifiable in 5.4% and 7.8% of the children respectively, which is in line with previous studies that reported numbers of up to 17% of non-identifiable peak values[15, 26, 36]. Our results revealed that both groups markedly differ from the overall study population with regard not only to later weight status but also BMI development during infancy and childhood. The observed differences in effect estimates comparing children with identifiable/non-identifiable IP/AR further suggest that associations between age/BMI at IP/AR and later weight status reported in previous studies may be biased due to the exclusion of children with non-identifiable IP/AR.

BMI at IP and AR correlated almost perfectly with BMI values at certain ages. The effect sizes of associations with later BMI z-score were also similar when using BMI values at fixed ages instead of BMI at IP or AR. This is in line with other studies that reported e.g. BMI at AR not to provide additional information in predicting adult weight status if the BMI at age 7 years (or 8 years) was known[37]. Hof et al.[15] found that BMI at age 9 months showed a similar association with body composition at 5 to 6 years as does the BMI at IP. A late IP or early AR may thus be just an indicator of children with higher-than average BMI values and/or higher-than-average BMI velocities[13]. BMI values at fixed ages provide more direct measures of later weight status and can be obtained in all children, i.e. their use avoids selection effects due to non-identifiability. Also for pediatricians who monitor children's growth it may be easier to identify children with higher-than-average BMI values (as typically determined based on percentile curves) than children with late IP or early AR or children that do not show an IP or AR.

When assessing associations between different BMI growth measures and later weight status, the use of non-standardized (raw) BMI measures may be problematic as effect estimates cannot be directly compared between exposures with different units, mean values and standard deviations. For example, raw BMI values are typically lowest from approximately age 3 to 6 years (time period of AR) such that a one unit increase in this period can be expected to show a higher effect estimate compared to BMI values at other ages when using raw values. The use of standardized exposure measures solved this problem. Consequently, estimation of associations using raw BMI growth measures led to somewhat differing results (see Table S2 in the supplementary material): For instance, the largest association for the raw BMI values with later weight status was observed at 4 years in the total study group with effect estimates being similar at 3 and 5 years whereas associations between standardized BMI values with later weight status increased with age and were largest for BMI values at 7 and 8 years. Analogously, the raw AUC from birth to 2 years but the standardized AUC from birth to 8 years showed the largest associations with later weight status.

As associations with later weight status were stronger for BMI values at older ages compared to BMI at IP or AR, our results do not support the conclusion that the IP or AR are critical periods for later weight status as discussed earlier[13, 20, 38]. Growth velocities were most predictive for later weight status at ages 5 and 6 which corresponds to the period of school entry that is typically accompanied by lifestyle changes including reduced physical activity[39, 40]. Furthermore, observing the highest effect estimate for the AUC covering the largest time span, i.e. the from birth to 8 years, is in line with the accumulation of risk model (which is the notion that life course exposures may lead to cumulative damage as the severity, duration, and number of exposures increases)[41, 42].

Estimation of age and BMI at IP and AR is likely to depend on the numbers of repeated BMI measurements available, on the sample size as well as on the approach chosen for determining the IP and AR. Multi-level models offer several advantages over other growth modeling techniques[25, 27, 28, 36, 43]. However, there are various choices of more complex multi-level models compared to our model (like higher degree fractional polynomials or penalized spline models with random coefficients). But also these models face the problem of non-identifiability of the IP or AR in certain children as has been reported e.g. using higher-order fractional polynomial models in Wen et al.[26] as well as applying the penalized spline approach for identification of age/BMI at IP[18]. In line with our study, Silverwood et al.[18]

mentioned as a main reason for subjects not having an identified BMI peak that their BMI observations continued to increase over the first few years of life.

As the number of BMI measurements strongly differed between children in our sample (range: 4 up to 22 measurements), sensitivity analyses were conducted to check whether the number of available BMI measurements per child affects identifiability of the IP and AR. Comparing children with identifiable vs. non-identifiable IP and AR, mean numbers of available BMI measurements per child were almost equal. Also when limiting our dataset to children with at least 6 or at least 8 repeated measurements, respectively, the percentage of children with non-identifiable IP and AR remained almost unchanged compared to the full analysis group. Numbers of available measurements and corresponding inclusion criteria strongly differ between studies ranging from 3[15] up to ≥18[26] available BMI measurements per child. Nevertheless, also the latter study reported the problem of non-identifiable IP and AR. As a guidance, Cole suggested to have at least three BMI measurements spread over several years to identify the AR[13].

Limitations and strengths

As discussed above, the choice of the growth modeling approach may affect the estimation of the BMI trajectory and hence of the IP and AR. In large epidemiological studies with few repeated measurements, multi-level models offer a powerful tool for growth modeling and enable handling of unbalanced data under a missing at random assumption. This assumption is less strict compared to the missing completely at random assumption that is e.g. required for complete cases analyses. In our sample, the assumption seemed justified as missing BMI values may mainly result from the differing schedules of the routine child visits in the single countries. However, it has to be acknowledged that the assumption cannot be proven formally. Deriving exposure measures based on trajectories and then relating the derived exposures to a certain outcome is commonly referred to as two-step approach[44]. In the present analysis, the uncertainty in the estimates of the exposures derived in step one has not been taken into account which is certainly a limitation. However, this limitation applies to all of the derived exposures and models and is hence unlikely to alter our conclusions. Furthermore, our regression models were adjusted only for sex and study center. The main purpose of the models was to derive comparable effect estimates and to illustrate a potential selection effect when excluding children with non-identifiable IP or AR but not to assess fully adjusted effect estimates for the single exposures. As (time-varying) confounders like physical activity or diet differ depending on the age at exposure assessment (e.g. energy intake at 5 years may be related to subsequent but not previous BMI values), consideration of further confounders would have limited comparability of effect estimates and also reduced the size of the analysis sample (due to incomplete covariate information).

Our mean age at outcome assessment was 9.2 years, different results may be observed for other ages at outcome assessment limiting also the comparability between studies.

To our knowledge, this is the first study that discusses a potential selection effect that may result from the exclusion of children with non-identifiable IP or AR when relating age/BMI at IP or AR to a later health outcome. We hope that we were able to raise the awareness of researchers for potential selection effects and would like to encourage researchers to carefully check subgroups of children being excluded.

Conclusions

Associations between BMI growth characteristics in infancy and childhood and later BMI z-scores were largest for the most recent BMI values whereas BMI growth velocities at 5 and 6 years showed the strongest associations. Age and BMI at IP and AR may not be estimable in children with markedly higher-than-average BMI growth. Excluding these children from subsequent analyses may thus result in a selection bias. BMI values at age 1 and 5 years perfectly correlated with BMI at IP and AR, respectively, are easier to interpret and might hence be more appropriate predictors for later weight status or disease risk.

Supplementary information is available at International Journal of Obesity's website (supplementary material file S1 including Table S1 and Table S2).

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Contributor's statement

Each author has seen and approved the contents of the submitted manuscript. All authors contributed to conception and design, acquisition of data, analysis or interpretation of data. Final approval of the version published was given by all the authors. All the authors revised the article critically for important intellectual content.

Ethics statement

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research, and that the IDEFICS/I.Family projects passed the Ethics Review process of the Sixth Framework Programme (FP6) and Seventh Framework Programme (FP7) of the European Commission. Ethical approval was obtained from the relevant local or national ethics committees by each of the eight study centers, namely from the Ethics Committee of the University Hospital Ghent (Belgium), the National Bioethics Committee of Cyprus (Cyprus), the Tallinn Medical Research Ethics Committee of the National Institutes for Health Development (Estonia), the Ethics Committee of the University Bremen (Germany), the Scientific and Research Ethics Committee of the Medical Research Council Budapest (Hungary), the Ethics Committee of the Health Office Avellino (Italy), the Ethics Committee for Clinical Research of Aragon (Spain), and the Regional Ethics Review Board of Gothenburg (Sweden). All children aged 12 years or older and parents or legal guardians of younger children gave written informed consent to data collection, examinations, collection of samples, subsequent analysis and storage of personal data and collected samples. Additionally, children younger than 12 years child gave oral consent after being orally informed about the modules by a study nurse immediately before every examination using a simplified text. The oral consenting process was not further documented, but it was subject to central and local training and quality control procedures of the study. Study participants and their parents/legal guardians could consent to single components of the study while abstaining from others. All procedures were approved by the above-mentioned Ethics Committees.

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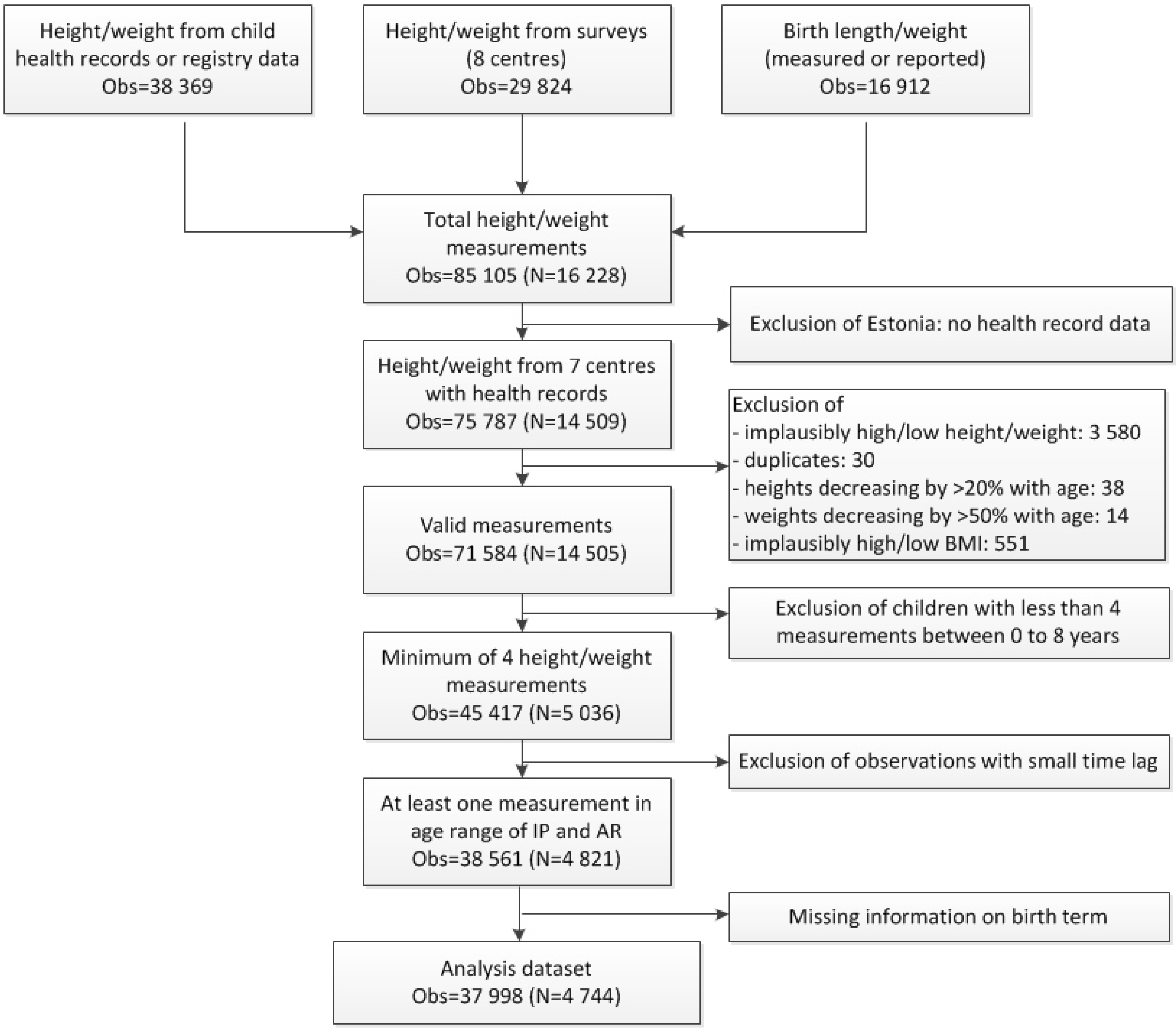
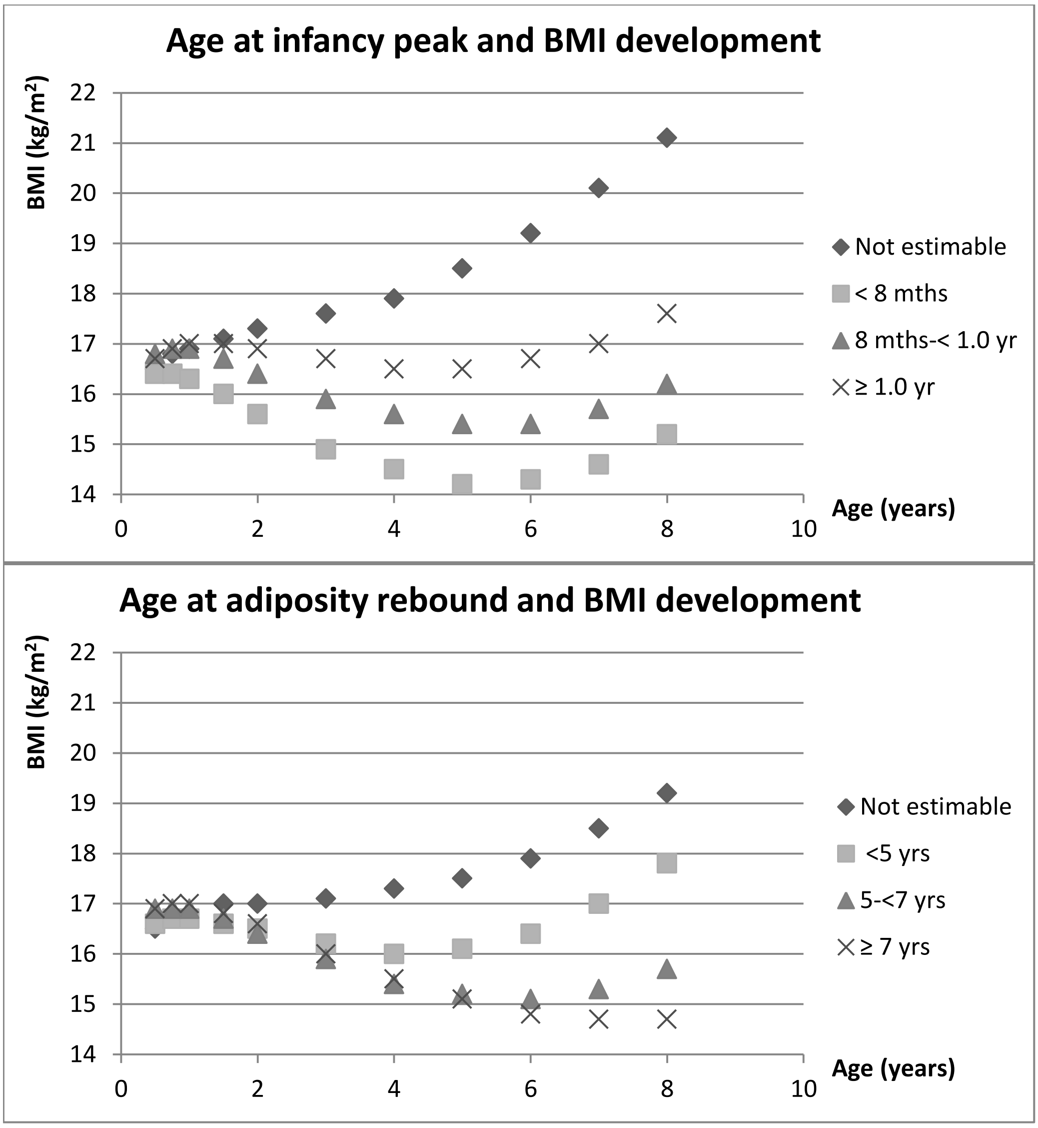
Figure 1: Data flow chart describing the exclusion process leading to the final analysis sample

Figure 2: Mean estimated BMI values at selected ages in children with early, medium, late or non-estimable infancy peak (top) and early, medium, late or non-estimable adiposity rebound (buttom)


Height/weight from child health records or registry data Obs=38 369
Height/weight from surveys (8 centres) Obs=29 824
Birth length/weight (measured or reported) Obs=16 912
Total height/weight measurements Obs=85 105 (N=16 228)
Exclusion of Estonia: no health record data
Height/weight from 7 centres with health records Obs=75 787 (N=14 509)
Exclusion of
- implausibly high/low height/weight: 3 580
- duplicates: 30
- heights decreasing by >20% with age: 38
- weights decreasing by >50% with age: 14
- implausibly high/low BMI: 551
Valid measurements Obs=71 584 (N=14 505)
Exclusion of children with less than 4 measurements between 0 to 8 years
Minimum of 4 height/weight measurements Obs=45 417 (N=5 036)
Exclusion of observations with small time lag
At least one measurement in age range of IP and AR Obs=38 561 (N=4 821)
Missing information on birth term
Analysis dataset Obs=37 998 (N=4 744)


Age at infancy peak and BMI development
BMI (kg/m²)
22
21
20
19
18
17
16
15
14
0
2
4
6
8
10
Age (years)
Not estimable
< 8 mths
8 mths-< 1.0 yr
≥ 1.0 yr
Age at adiposity rebound and BMI development
BMI (kg/m²)
22
21
20
19
18
17
16
15
14
0
2
4
6
8
10
Age (years)
Not estimable
<5 yrs
5-<7 yrs
≥ 7 yrs

	Age at infancy peak (mean: 0.9 years)								Age at adiposity rebound (mean: 5.2 years)									
	Not estimable		< 8 mths		8 mths-< 1.0 yr		≥ 1.0 yr		Not estimable		<5 yrs		5-<7 yrs		≥ 7 yrs		All	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Sex																		
Boys	154	59.9	177	37.2	1 490	50.5	639	60.2	221	59.6	931	57.2	1 247	48.2	61	38.6	2 460	51.9
Girls	103	40.1	299	62.8	1 460	49.5	422	39.8	150	40.4	697	42.8	1 340	51.8	97	61.4	2 284	48.1
Weight status at last follow-up*																		
Thin	3	1.2	151	31.7	292	9.9	26	2.5	33	8.9	37	2.3	354	13.7	48	30.4	472	9.9
Normal weight	58	22.6	299	62.8	2 339	79.3	710	66.9	133	35.8	1 054	64.7	2 111	81.6	108	68.4	3406	71.8
Overweight	99	38.5	25	5.3	289	9.8	262	24.7	107	28.8	452	27.8	114	4.4	2	1.3	675	14.2
Obese	97	37.7	1	0.2	30	1.0	63	5.9	98	26.4	85	5.2	8	0.3	-	-	191	4.0
Birth term																		
Born in time	192	74.7	387	81.3	1 938	65.7	668	63.0	277	74.7	1 050	64.5	1 749	67.6	109	69.0	3 185	67.1
Pre-term birth	65	25.3	89	18.7	1 012	34.3	393	37.0	94	25.3	578	35.5	838	32.4	49	31.0	1 559	32.9
All	257	5.4	476	10.0	2 950	62.2	1 061	22.4	371	7.8	1 628	34.3	2 587	54.5	158	3.3	4 744	100

Table 1: Description of the study population: Distributions of sex, weight status at last available follow-up measurement (mean age: 9.2 years) and birth term (< vs. ≥ 37th gestational week) by categories of the infancy peak and adiposity rebound (mths=months, yrs=years)

*BMI classification according to Cole & Lobstein[32]
Percentages may not add up to 100% due to rounding.

	Age at infancy peak (mean: 0.9 years)												Age at adiposity rebound (mean: 5.2 years)														
	Not estimable			< 8 months			8 months-< 1.0 year			≥ 1.0 year			Not estimable			<5 years			5-<7 years			≥ 7 years			All		
	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL
BMI at age																											
0.5	16.5	16.3	16.7	16.4	16.3	16.5	16.8	16.8	16.9	16.7	16.7	16.8	16.5	16.3	16.6	16.6	16.5	16.7	16.9	16.8	16.9	16.9	16.7	17.0	16.7	16.7	16.8
0.75	16.8	16.6	16.9	16.4	16.3	16.5	16.9	16.9	17.0	16.9	16.8	17.0	16.7	16.6	16.8	16.7	16.7	16.8	16.9	16.9	17.0	17.0	16.8	17.2	16.9	16.8	16.9
1	16.9	16.8	17.1	16.3	16.2	16.4	16.9	16.8	16.9	17.0	16.9	17.1	16.8	16.7	17.0	16.7	16.7	16.8	16.9	16.9	17.0	17.0	16.8	17.2	16.9	16.8	16.9
1.5	17.1	17.0	17.3	16.0	15.9	16.0	16.7	16.7	16.7	17.0	16.9	17.1	17.0	16.8	17.1	16.6	16.6	16.7	16.7	16.7	16.8	16.8	16.7	17.0	16.7	16.7	16.7
2	17.3	17.1	17.5	15.6	15.5	15.7	16.4	16.4	16.5	16.9	16.8	17.0	17.0	16.9	17.2	16.5	16.4	16.5	16.4	16.4	16.5	16.6	16.4	16.7	16.5	16.5	16.5
3	17.6	17.4	17.8	14.9	14.9	15.0	15.9	15.9	16.0	16.7	16.6	16.7	17.1	16.9	17.3	16.2	16.1	16.2	15.9	15.8	15.9	16.0	15.9	16.2	16.1	16.0	16.1
4	17.9	17.7	18.2	14.5	14.4	14.5	15.6	15.5	15.6	16.5	16.5	16.6	17.3	17.1	17.5	16.0	16.0	16.1	15.4	15.4	15.5	15.5	15.3	15.7	15.8	15.8	15.8
5	18.5	18.2	18.7	14.2	14.2	14.3	15.4	15.3	15.4	16.5	16.4	16.6	17.5	17.3	17.8	16.1	16.0	16.2	15.2	15.2	15.2	15.1	14.9	15.3	15.7	15.6	15.7
6	19.2	18.9	19.4	14.3	14.2	14.4	15.4	15.4	15.5	16.7	16.6	16.8	17.9	17.7	18.2	16.4	16.3	16.5	15.1	15.1	15.2	14.8	14.6	15.0	15.8	15.7	15.8
7	20.1	19.8	20.4	14.6	14.5	14.7	15.7	15.6	15.7	17.0	16.9	17.1	18.5	18.2	18.8	17.0	16.9	17.0	15.3	15.3	15.4	14.7	14.5	14.9	16.1	16.1	16.2
8	21.1	20.8	21.5	15.2	15.1	15.3	16.2	16.2	16.3	17.6	17.5	17.7	19.2	18.8	19.6	17.8	17.7	17.9	15.7	15.7	15.8	14.7	14.5	14.9	16.7	16.6	16.7
Velocity (kg/m^2/year) at age																											
0.5	1.4	1.4	1.5	0.3	0.3	0.3	0.8	0.8	0.8	1.2	1.1	1.2	1.3	1.3	1.4	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.8	0.9
0.75	0.8	0.8	0.9	-0.3	-0.3	-0.3	0.1	0.1	0.1	0.5	0.5	0.5	0.7	0.6	0.7	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2
1	0.5	0.5	0.6	-0.5	-0.6	-0.5	-0.2	-0.2	-0.2	0.1	0.1	0.1	0.4	0.4	0.4	-0.1	-0.1	-0.1	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1
1.5	0.3	0.3	0.4	-0.7	-0.7	-0.7	-0.5	-0.5	-0.5	-0.1	-0.1	-0.1	0.2	0.1	0.2	-0.3	-0.3	-0.3	-0.5	-0.5	-0.5	-0.4	-0.5	-0.4	-0.4	-0.4	-0.4
2	0.3	0.2	0.3	-0.7	-0.7	-0.7	-0.5	-0.5	-0.5	-0.2	-0.2	-0.2	0.1	0.0	0.1	-0.3	-0.3	-0.3	-0.6	-0.6	-0.6	-0.5	-0.6	-0.5	-0.4	-0.4	-0.4
3	0.3	0.3	0.3	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.2	-0.2	-0.2	0.1	0.1	0.1	-0.2	-0.2	-0.2	-0.5	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	-0.4	-0.4
4	0.4	0.4	0.5	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.1	-0.1	-0.1	0.2	0.2	0.2	0.0	-0.1	0.0	-0.4	-0.4	-0.3	-0.5	-0.5	-0.4	-0.2	-0.2	-0.2
5	0.6	0.6	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.2	0.2	0.2	-0.2	-0.2	-0.1	-0.3	-0.4	-0.3	0.0	0.0	0.0
6	0.8	0.7	0.8	0.2	0.1	0.2	0.2	0.1	0.2	0.3	0.2	0.3	0.5	0.4	0.5	0.4	0.4	0.4	0.1	0.1	0.1	-0.2	-0.2	-0.2	0.2	0.2	0.2
7	1.0	0.9	1.0	0.5	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.3	0.3	0.3	-0.1	-0.1	0.0	0.4	0.4	0.5
8	1.2	1.1	1.3	0.8	0.7	0.8	0.6	0.6	0.7	0.6	0.6	0.7	0.8	0.7	0.9	1.0	0.9	1.0	0.5	0.5	0.5	0.1	0.1	0.1	0.7	0.7	0.7
AUC																											
0.01 to 2 yrs	33.2	32.9	33.6	31.9	31.8	32.1	33.0	33.0	33.1	33.2	33.1	33.4	33.0	32.8	33.3	32.8	32.7	32.9	33.1	33.0	33.2	33.2	32.9	33.6	33.0	32.9	33.1
0.01 to 5 yrs	86.6	85.7	87.6	76.2	75.8	76.6	80.4	80.2	80.6	83.1	82.8	83.5	84.7	83.9	85.5	81.3	81.0	81.6	80.2	80.0	80.4	80.6	79.8	81.3	80.9	80.8	81.1
0.01 to 8 yrs	145.7	143.9	147.5	119.7	119.1	120.3	127.3	127.0	127.5	133.9	133.3	134.5	139.5	137.8	141.1	131.5	131.1	132.0	126.1	125.8	126.4	124.9	123.7	126.2	129.0	128.7	129.3
Age at last follow-up	9.1	8.8	9.5	9.3	9.1	9.6	9.2	9.1	9.3	9.2	9.0	9.4	9.3	9.0	9.6	9.0	8.9	9.2	9.2	9.1	9.3	9.9	9.6	10.3	9.2	9.1	9.3
BMI z-score at last follow-up	1.9	1.8	2.0	-0.5	-0.6	-0.4	0.1	0.1	0.1	0.8	0.7	0.8	1.2	1.0	1.3	0.8	0.8	0.9	-0.1	-0.1	-0.1	-0.6	-0.7	-0.5	0.3	0.3	0.3

Table 2: Estimated BMI values and BMI velocities (kg/m^2/year) at selected ages, AUC measures as well as mean age and BMI at last follow-up in children with early, medium and late infancy peak or adiposity rebound as well as for children with non-estimable infancy peak or adiposity rebound and for the total study group
AUC: area under the BMI growth curve, LCL: lower 95% confidence interval, UCL: upper 95% confidence interval

	Age at IP		BMI at IP		Age at AR		BMI at AR	
BMI at age	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**
0.5	0.03	0.075	1.00	<.0001	0.11	<.0001	0.71	<.0001
0.75	0.08	<.0001	1.00	<.0001	0.09	<.0001	0.74	<.0001
1	0.13	<.0001	1.00	<.0001	0.07	<.0001	0.77	<.0001
1.5	0.22	<.0001	0.99	<.0001	0.03	0.0427	0.82	<.0001
2	0.30	<.0001	0.97	<.0001	-0.02	0.2009	0.87	<.0001
3	0.43	<.0001	0.91	<.0001	-0.14	<.0001	0.94	<.0001
4	0.52	<.0001	0.84	<.0001	-0.28	<.0001	0.98	<.0001
5	0.55	<.0001	0.75	<.0001	-0.42	<.0001	0.99	<.0001
6	0.54	<.0001	0.68	<.0001	-0.54	<.0001	0.98	<.0001
7	0.48	<.0001	0.61	<.0001	-0.64	<.0001	0.94	<.0001
8	0.40	<.0001	0.56	<.0001	-0.71	<.0001	0.88	<.0001
Velocity at age								
0.5	0.69	<.0001	0.58	<.0001	-0.13	<.0001	0.75	<.0001
0.75	0.87	<.0001	0.28	<.0001	-0.27	<.0001	0.70	<.0001
1	0.89	<.0001	0.03	0.0349	-0.35	<.0001	0.58	<.0001
1.5	0.82	<.0001	-0.20	<.0001	-0.45	<.0001	0.43	<.0001
2	0.75	<.0001	-0.29	<.0001	-0.54	<.0001	0.38	<.0001
3	0.64	<.0001	-0.31	<.0001	-0.72	<.0001	0.38	<.0001
4	0.47	<.0001	-0.23	<.0001	-0.87	<.0001	0.41	<.0001
5	0.28	<.0001	-0.10	<.0001	-0.93	<.0001	0.43	<.0001
6	0.11	<.0001	0.03	0.0896	-0.90	<.0001	0.41	<.0001
7	-0.01	0.464	0.12	<.0001	-0.83	<.0001	0.39	<.0001
8	-0.09	<.0001	0.18	<.0001	-0.77	<.0001	0.36	<.0001
AUC								
0.01 to 2 years	0.13	<.0001	0.06	<.0001	1.00	<.0001	0.77	<.0001
0.01 to 5 years	0.35	<.0001	-0.11	<.0001	0.95	<.0001	0.91	<.0001
0.01 to 8 years	0.44	<.0001	-0.34	<.0001	0.85	<.0001	0.97	<.0001

Table 3: Pearson correlations between estimated ages and BMI at infancy peak (IP) and adiposity rebound (AR) with estimated BMI values and BMI velocities at selected ages and areas under the curve (AUC); only children with estimable age/BMI at IP (N=4 487) and AR (N=4 373) were considered, respectively (p-values are added for exploratory purposes, only)

	IP not estimable			IP estimable			AR not estimable			AR estimable			All		
	β	LCL	UCL	β	LCL	UCL	β	LCL	UCL	β	LCL	UCL	β	LCL	UCL
BMI z-score at age (years)															
0.5	0.42	0.34	0.50	0.49	0.46	0.51	0.48	0.36	0.59	0.48	0.46	0.51	0.47	0.44	0.50
0.75	0.42	0.34	0.50	0.50	0.48	0.53	0.50	0.39	0.62	0.50	0.48	0.53	0.50	0.47	0.52
1	0.42	0.34	0.50	0.52	0.50	0.55	0.53	0.42	0.64	0.52	0.49	0.55	0.52	0.50	0.55
1.5	0.42	0.34	0.49	0.56	0.54	0.59	0.58	0.48	0.68	0.56	0.54	0.59	0.58	0.55	0.60
2	0.42	0.35	0.49	0.60	0.58	0.63	0.63	0.54	0.72	0.61	0.58	0.63	0.63	0.61	0.65
3	0.43	0.37	0.50	0.70	0.67	0.72	0.70	0.63	0.78	0.70	0.68	0.73	0.72	0.69	0.74
4	0.46	0.40	0.52	0.80	0.77	0.82	0.75	0.68	0.81	0.80	0.78	0.82	0.78	0.76	0.80
5	0.49	0.43	0.55	0.89	0.87	0.91	0.76	0.70	0.81	0.89	0.86	0.91	0.83	0.81	0.84
6	0.51	0.45	0.57	0.95	0.93	0.97	0.74	0.70	0.79	0.95	0.92	0.97	0.85	0.84	0.87
7	0.52	0.46	0.58	0.98	0.96	1.00	0.72	0.68	0.76	0.97	0.95	0.99	0.87	0.85	0.88
8	0.51	0.45	0.57	0.96	0.94	0.98	0.69	0.65	0.73	0.97	0.94	0.99	0.86	0.85	0.88
BMI velocity z-score at age (years)															
0.5	0.36	0.28	0.43	0.52	0.49	0.55	0.59	0.50	0.68	0.54	0.52	0.57	0.57	0.54	0.59
0.75	0.37	0.29	0.46	0.53	0.49	0.56	0.69	0.60	0.78	0.56	0.53	0.60	0.56	0.54	0.59
1	0.39	0.29	0.48	0.47	0.43	0.5	0.75	0.66	0.84	0.51	0.47	0.54	0.52	0.49	0.55
1.5	0.41	0.30	0.52	0.39	0.36	0.43	0.79	0.71	0.88	0.42	0.39	0.46	0.47	0.44	0.50
2	0.45	0.33	0.57	0.40	0.37	0.44	0.79	0.71	0.88	0.42	0.39	0.46	0.48	0.45	0.51
3	0.53	0.42	0.64	0.53	0.49	0.56	0.70	0.63	0.78	0.53	0.50	0.57	0.55	0.53	0.58
4	0.51	0.42	0.60	0.66	0.63	0.69	0.66	0.60	0.71	0.66	0.63	0.70	0.64	0.61	0.66
5	0.44	0.36	0.52	0.70	0.67	0.73	0.60	0.55	0.65	0.72	0.69	0.75	0.68	0.65	0.70
6	0.39	0.32	0.47	0.67	0.64	0.69	0.57	0.52	0.62	0.70	0.67	0.73	0.67	0.65	0.69
7	0.36	0.29	0.43	0.62	0.59	0.64	0.56	0.51	0.61	0.65	0.62	0.68	0.64	0.61	0.66
8	0.34	0.27	0.41	0.57	0.55	0.60	0.56	0.50	0.61	0.61	0.58	0.63	0.60	0.57	0.62
AUC: 0.01 to 2 years (z-score)	0.42	0.34	0.50	0.53	0.50	0.56	0.55	0.44	0.65	0.53	0.50	0.55	0.53	0.51	0.56
AUC: 0.01 to 5 years (z-score)	0.44	0.37	0.51	0.67	0.65	0.70	0.70	0.62	0.78	0.67	0.65	0.70	0.70	0.68	0.72
AUC: 0.01 to 8 years (z-score)	0.48	0.42	0.54	0.83	0.81	0.85	0.75	0.70	0.81	0.83	0.81	0.85	0.81	0.79	0.83
BMI z-score at IP/AR§				0.51	0.48	0.53				0.75	0.73	0.77			
Age z-score at IP/AR§				0.36	0.33	0.39				-0.55	-0.58	-0.53			
IP estimable vs. non-estimable #													-1.54	-1.67	-1.42
AR estimable vs. non-estimable #													-0.86	-0.96	-0.75

Table 4: Effect estimates and 95% confidence intervals for the associations of standardized BMI values and velocities at selected ages, AUC measures and ages/BMI at IP and AR with BMI z-score at last follow-up in groups of children with (non)estimable infancy peak and adiposity rebound as well as for the total study group. All models were adjusted for sex and study center.

§The estimated age and BMI at infancy peak was related to later BMI z-score in the group of children with calculable infancy peak; the age and BMI at adiposity was related to later BMI z-score in the group of children with calculable adiposity rebound

#Dummy variables indicating whether the infancy peak or adiposity rebound were identifiable were related to later BMI z-score

AUC: area under the BMI growth curve

LCL: lower 95% confidence interval

UCL: upper 95% confidence interval

Supplementary material S1

	Boys			Girls			All		
	N	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
0 to <0.5 years	6070	3.6	1.4	5058	3.5	1.3	11128	3.5	1.4
0.5 to <1 year	2298	3.4	1.2	2454	3.4	1.2	4752	3.4	1.2
1 to <2 years	3359	3.5	1.1	3103	3.5	1.0	6462	3.5	1.1
2 to <3 years	1670	2.1	1.1	1520	2.0	1.1	3190	2.1	1.1
3 to <4 years	1031	2.5	1.1	965	2.4	1.1	1996	2.5	1.1
4 to <5 years	1645	2.6	1.0	1475	2.7	1.0	3120	2.7	1.0
5 to <6 years	1714	2.5	1.1	1700	2.5	1.1	3414	2.5	1.1
6 to <7 years	973	1.7	1.1	869	1.7	1.0	1842	1.7	1.1
7 to ≤8 years	1089	1.7	1.0	1005	1.6	1.0	2094	1.7	1.0
All	19849			18149			37998		

Table S1: Total number of BMI measurements and mean number of BMI measurements per child in the analysis group by age category and sex

SD: Standard deviation

	IP not estimable			IP estimable			AR not estimable			AR estimable			All		
	β	LCL	UCL	β	LCL	UCL	β	LCL	UCL	β	LCL	UCL	β	LCL	UCL
BMI at age															
0.5	0.38	0.31	0.46	0.44	0.42	0.46	0.43	0.33	0.54	0.44	0.41	0.46	0.42	0.40	0.45
0.75	0.37	0.30	0.44	0.44	0.42	0.47	0.44	0.35	0.54	0.44	0.42	0.46	0.44	0.41	0.46
1	0.37	0.30	0.43	0.46	0.43	0.48	0.46	0.37	0.56	0.45	0.43	0.48	0.46	0.43	0.48
1.5	0.36	0.30	0.43	0.49	0.46	0.51	0.50	0.42	0.59	0.49	0.46	0.51	0.50	0.48	0.52
2	0.36	0.30	0.42	0.52	0.50	0.54	0.54	0.46	0.62	0.52	0.50	0.54	0.54	0.52	0.56
3	0.36	0.30	0.41	0.58	0.56	0.60	0.58	0.52	0.65	0.58	0.56	0.60	0.59	0.58	0.61
4	0.35	0.30	0.40	0.61	0.60	0.63	0.57	0.53	0.62	0.62	0.60	0.63	0.60	0.58	0.62
5	0.34	0.30	0.38	0.62	0.60	0.63	0.53	0.49	0.56	0.61	0.60	0.63	0.57	0.56	0.59
6	0.31	0.28	0.35	0.58	0.57	0.60	0.46	0.43	0.49	0.58	0.57	0.59	0.52	0.51	0.54
7	0.28	0.25	0.31	0.52	0.51	0.54	0.39	0.36	0.41	0.52	0.51	0.53	0.47	0.46	0.47
8	0.24	0.21	0.26	0.45	0.44	0.46	0.32	0.30	0.34	0.45	0.44	0.46	0.40	0.39	0.41
BMI velocity at age															
0.5	0.91	0.72	1.10	1.34	1.27	1.41	1.51	1.28	1.74	1.39	1.32	1.47	1.45	1.39	1.52
0.75	1.21	0.93	1.48	1.71	1.61	1.81	2.24	1.96	2.52	1.83	1.73	1.94	1.83	1.74	1.91
1	1.32	0.99	1.65	1.59	1.48	1.71	2.57	2.27	2.87	1.73	1.61	1.85	1.77	1.68	1.86
1.5	1.42	1.03	1.81	1.37	1.25	1.49	2.76	2.45	3.06	1.47	1.35	1.59	1.64	1.54	1.73
2	1.60	1.18	2.01	1.43	1.30	1.55	2.82	2.53	3.10	1.50	1.37	1.62	1.69	1.60	1.79
3	1.97	1.56	2.38	1.97	1.84	2.10	2.76	2.52	3.01	1.99	1.86	2.12	2.07	1.97	2.17
4	1.94	1.59	2.29	2.51	2.39	2.64	2.50	2.29	2.71	2.53	2.40	2.65	2.42	2.33	2.52
5	1.60	1.31	1.89	2.52	2.42	2.63	2.15	1.97	2.33	2.59	2.48	2.70	2.44	2.35	2.52
6	1.25	1.01	1.49	2.13	2.04	2.22	1.82	1.66	1.98	2.23	2.13	2.32	2.14	2.06	2.22
7	0.99	0.79	1.19	1.70	1.62	1.77	1.54	1.39	1.68	1.79	1.71	1.87	1.75	1.69	1.82
8	0.80	0.63	0.97	1.35	1.29	1.41	1.31	1.18	1.44	1.43	1.36	1.49	1.41	1.35	1.47
AUC: 0.01 to 2 years	0.19	0.16	0.23	0.24	0.23	0.26	0.25	0.20	0.30	0.24	0.23	0.26	0.25	0.23	0.26
AUC: 0.01 to 5 years	0.08	0.07	0.09	0.12	0.11	0.12	0.12	0.11	0.14	0.12	0.11	0.12	0.12	0.12	0.13
AUC: 0.01 to 8 years	0.05	0.04	0.05	0.08	0.08	0.08	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
BMI at IP/AR§				0.45	0.43	0.47				0.62	0.61	0.64			
Age at IP/AR§				1.42	1.31	1.52				-0.55	-0.58	-0.53			
IP estimable vs. non-estimable #													-1.54	-1.67	-1.42
AR estimable vs. non-estimable #													-0.86	-0.96	-0.75

Table S2: Effect estimates and 95% confidence intervals for the associations of raw BMI values and velocities (kg/m^2/year) at selected ages, AUC measures and ages/BMI at IP and AR with later BMI z-score in groups of children with (non)estimable infancy peak and adiposity rebound as well as for the total study group. All models were adjusted for sex and study center.

§The estimated age and BMI at infancy peak was related to later BMI z-score in the group of children with calculable infancy peak; the age and BMI at adiposity was related to later BMI z-score in the group of children with calculable adiposity rebound

#Dummy variables indicating whether the infancy peak or adiposity rebound were identifiable were related to later BMI z-score
AUC: area under the BMI growth curve
LCL: lower 95% confidence interval
UCL: upper 95% confidence interval