

Growth of Belgian and Norwegian children compared to the WHO growth standards: Prevalence below -2 and above +2 standard deviations and the effect of breastfeeding

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Abstract

Background: New national growth references have been published in Belgium and Norway. The WHO recommends universal use of their 2006 child growth standards, based on data from breastfed children.

Objective: To compare the growth of Belgian and Norwegian children with the WHO standards.

Participants: 6985 children 0 - 5 years of age from Belgium and Norway.

Design: Proportion of children below -2 SD and above $+2$ SD of the WHO standards was calculated for length/height, weight, body mass index and head circumference. Average SD-scores of exclusively breastfed children of non-smoking mothers were compared with national reference data and with the WHO standards.

Results: Generally, the number of Belgian and Norwegian children below -2 SD lines of the WHO standards was lower, and above $+2$ SD higher than expected. The largest differences were for head circumference (0.97% Belgian and 0.18% Norwegian children below -2 SD, 6.55% Belgian and 6.40% Norwegian children above $+2$ SD), and the smallest for length/height (1.25% Belgian and 1.43% Norwegian children below -2 SD, 3.47% Belgian and 2.81% Norwegian children above $+2$ SD). The growth pattern of breastfed children of non-smoking mothers was in both countries more alike the local national growth references than the WHO standards.

Conclusions: There are significant deviations in the proportion of children outside normal limits (± 2 SD) of the WHO standards. This was true for all children, including those who were exclusively breastfed. Hence, adoption of the WHO growth charts could have consequences for clinical decision making. These findings advocate the use of national references in Belgium and Norway, also for breastfed children.

Background

Because of the variations in growth between populations, there has been a long tradition of constructing growth references aimed at specific target populations. Recently, new national growth references from birth to adulthood were published for Belgian¹ and Norwegian children². In 2006, the World Health Organization also issued universal growth standards, that intend to show how children grow under optimal conditions (hence "standards"), irrespective from which world region or population they originate (hence "universal")³. To achieve this goal the WHO set up a multicentre growth reference study (MGRS) in six countries (Brazil, Ghana, India, Norway, Oman, USA), and only included children of high social class (except in Norway and the USA where social class was not an inclusion criterion), of non-smoking mothers, that were breastfed according to recommendations⁴. The results for length demonstrated that differences between the six countries were relatively small (although the medians differed up to 0.5 SD at certain ages), and universal use of these charts for all children worldwide was therefore recommended⁵. To this date, site differences for weight, BMI or head circumference have not been reported.

The WHO growth standards represent an improvement over the previous United States National Centre for Health Statistics (NCHS) based growth reference charts, but the implementation is nevertheless not straightforward in developed countries where updated references are available. Children in Hong Kong have shown to be shorter when compared with the WHO standard⁶, and children in the Netherlands longer⁷. In the UK, birth weight and birth length have been found to be higher⁸, and consequently, the WHO standards were only adopted from two weeks of age and onwards. When comparing standard deviation scores for length/height, weight, BMI and head circumference, three of us (MR, KH and RH) have recently shown that Belgian breastfed children grow similar in length when compared with the WHO standards, but not for other traits like weight, BMI and head circumference⁹. Collectively, these observations challenge the validity of the WHO standards as a universal tool for growth monitoring that should replace local references⁷. This is an important issue since the choice of a local reference or the WHO international standards may affect thresholds used in clinical guidelines, and can therefore have considerable consequences for both patients, parents and the health care system.

The aim of the present study was to compare the proportion of Belgian and Norwegian children outside the normal limits (defined by ± 2 SD) of the WHO growth standards for length/height, weight, BMI and head circumference, with the expected number of 2.3%. A separate analysis was performed for children of a non-smoking mother breastfed according to recommendations.

Subjects and Methods

The Flanders Growth Study (FGS) is a representative cross-sectional survey of 18051 subjects 0 – 21 years of age, recruited in Flanders (northern part of Belgium), in 2001 – 4 (see ¹ for details). The Bergen Growth Study (BGS) is a cross-sectional survey of 8299 subjects 0 – 19 years of age, recruited in the city of Bergen, Norway in 2003 – 6 (see ² for details). The present analysis was limited to children of Belgian (n = 4754) and Norwegian (n = 2231) origin between 0 and 5 years of age. All children were healthy and born at term (37 – 42 weeks of gestational age), but low birth weight children born at term were not excluded (table 1).

Table 1. Number of children in the Belgian and Norwegian sample.

Age	Belgium			Norway		
	Boys	Girls	Total	Boys	Girls	Total
0 – 1	999	951	1949	601	558	1159
1 – 2	340	338	678	132	141	273
2 – 3	320	317	637	151	120	271
3 – 4	328	369	697	125	145	270
4 – 5	427	366	793	131	127	258
Total	2414	2340	4754	1140	1091	2231

The FGS and BGS are highly comparable in design and modus operandi and both surveys included biometry and an assessment of social status and infant feeding practice. Length (before 2 years of age), height (from 2 years of age), weight and head circumference were measured by trained staff members, using a standardised technique and equipment. Weight, length and head circumference at birth, feeding practice and smoking in pregnancy were recorded through a parental questionnaire in both studies. Children were considered as exclusively breastfed when they were breastfed for at least 6 months, and no formula milk was introduced before that age. This includes also children younger than 6 months who did not yet receive any formula milk at the time of measurement. Solids were not accounted for, but these are typically introduced between 4 and 6 months of age. A total of 683 Belgian and 527 Norwegian children were assigned to the exclusively breastfed subgroup (excluding 69 Belgian and 43 Norwegian children because of smoking during pregnancy). In addition, 304 Norwegian children were exclusively breastfed for at least 6 months but also received continuous breastfeeding (exclusive or not) up to at least 12 months of age (excluding 16 children because of smoking during pregnancy). Only 26 children in the Belgian sample met this criterion.

Statistical analysis

Subjects were grouped into 4 months interval between birth and one year of age and yearly intervals thereafter. The prevalence of children below and above certain thresholds for length, height, weight, BMI and head circumference is reported by age group or adjusted for age (per year) otherwise. For the analysis of breastfed children of non-smoking mothers all traits were converted to SD-scores according to the WHO growth standards ³. The reference group

consists of all children on which the Belgian and Norwegian growth charts are based, including the group of exclusively breastfed children by definition.

Means and proportions are always presented with 95% confidence intervals. Confidence intervals for simple proportions are the exact Clopper-Pearson 95% confidence limits ¹⁰. Age adjusted rates and confidence limits are based on the gamma distribution ¹¹, assuming an equal number of children in each age group. Size at birth was based on recall data from all subjects in the sample, and constitutes a separate age class. Global prevalence estimates are only based on postnatal growth measurements.

The Flanders Growth Study was approved by the ethics committee of the Vrije Universiteit Brussel, and the Bergen Growth Study by the Regional Committee for Medical Research Ethics and the Norwegian Data Inspectorate.

Results

Percentage of all children outside -2 SD and $+2$ SD.

Compared to the WHO growth standards, we generally saw fewer children below -2 SD and more children above $+2$ SD than expected (figure 1). Remarkably similar trends were observed in Belgian and Norwegian children.

At birth, the percentage of Belgian children below -2 SD was as expected for length, weight and head circumference, but too high for the BMI. The percentage of children above $+2$ SD was highly elevated for length (8%) and head circumference and comparable for weight and BMI. The percentage of Norwegian children below -2 SD at birth was as expected for length and BMI, but too low for weight and head circumference. The percentage of children above $+2$ SD was highly elevated for all variables, and up to 13% for length and head circumference.

The age-adjusted prevalence of all children 0-5 years of age with a *length* below -2 SD was 1.25% (0.92-1.65) in Belgium and 1.43% (0.90-2.17) in Norway. The corresponding percentage above $+2$ SD was 3.47% (2.90-4.14) and 2.81% (2.11-3.69) respectively. In both countries there was a tendency to converge with the WHO standard for length towards the older age groups, and the proportion of children outside normal limits became reasonably close to the expected amount of 2.3% by the age of three (figure 1). For *weight* the overall percentage below -2 SD was 0.65% (0.45-0.93) for Belgian and 0.56% (0.29-1.04) for Norwegian children. The percentage above $+2$ SD was respectively 3.08% (2.54-3.71) and 3.39% (2.56-4.44). Unlike for length, there was no apparent trend with age. A similar observation was made for the *BMI*, where the overall percentage below -2 SD was 0.84% (0.59-1.18) for Belgian and 0.54% (0.29-0.99) for Norwegian children. The corresponding percentage above $+2$ SD was 3.01% (2.45-3.67) and 4.29% (3.30-5.50). For *head circumference* the overall percentage below -2 SD was 0.97% (0.70-1.33) for Belgian and only 0.18% (0.05-0.53) for Norwegian children. The prevalence of children above $+2$ SD was relatively high, with respectively 6.55% (5.76-7.42) and 6.40% (5.19-7.83). Apart from birth, the largest discrepancy was observed between one and three years of age.

[FIGURE 1 ABOUT HERE]

The effect of breastfeeding

To document the effect of breastfeeding, we compared the growth of a subgroup of 1210 breastfed children born to a non-smoking mother with the WHO growth standards in both countries. This was done by comparing mean SD scores rather than the prevalence outside the normal range, because the number of children below -2 SD or above $+2$ SD would become too small. The prevalence of exclusive breastfeeding for at least 6 months was 26.5% in the Belgian sample⁹ and 40.6% in the Norwegian sample (based on recall data from children 6 months to 5 years of age). This analysis demonstrated that the growth of exclusively breastfed children was more similar to that of all children in the local population (including those that were not breastfed) than to the WHO growth standards (figure 2). Between 6 months and 2 years of age, Belgian breastfed children had generally a smaller length and less weight, and are therefore somewhat closer to the WHO growth standards, although the overall pattern was still more like that of the reference population. For Norwegian children this was true for weight and BMI. To document the possible additional effect of continuous breastfeeding up to at least 12 months of age, the growth of a subgroup of 304 Norwegian children that comply with these criteria was compared to those that were exclusively breastfed for 6 months (figure 3). The length and weight were highly similar in the two groups, and no additional effect

could be demonstrated in this study. Similar results were obtained for BMI and head circumference (data not shown).

[FIGURE 2 ABOUT HERE]

Discussion

In this paper, we have demonstrated significant deviations in the proportion of Belgian and Norwegian children that are located outside the normal limits of the WHO growth standards, generally defined as an SDS below -2 SD (2.3 percentile) or above $+2$ SD (97.7 percentile). Although these cut offs do not warrant immediate action or referral to specialized care, they are often included in clinical guidelines, and adoption of the WHO growth charts could therefore affect the clinical decision making process⁸. Compared to the WHO standards, the number of Belgian and Norwegian children below -2 SD is generally lower, and the number above $+2$ SD higher than expected, for length/height, weight, BMI and head circumference, with the largest discrepancy observed for head circumference. As the WHO standards are based on a sample of breastfed children born to a non-smoking mother, one could speculate that these differences mirror different inclusion criteria. However, our observation that the growth of exclusively breastfed children in both Belgium and Norway was generally closer to that of the local reference population than to that of the WHO standards, refutes this hypothesis, and probably reflects that genetic and environmental background factors have stronger influence on growth than feeding practices. This perception is strengthened by the similarity of the growth patterns observed in both countries as compared to the WHO growth standards.

In the present study, criteria for exclusive breastfeeding were chosen to mimic those of the MGRS. These criteria differ slightly from current WHO recommendations, which advise the introduction of solids at the age of 6 months¹². In the MGRS, the previous recommendation of introducing solids between 4 and 6 months of age was used. Solids were not accounted for in the present study, but it was previously shown that only a minority of breastfed children received solids before the age of 4 months^{13 14}. In children older than 2 years, the MGRS inclusion criteria were less strict (at least 3 months of predominant breastfeeding, with no additional requirements about complimentary foods), while we applied the same definition throughout the whole age range. Due to the cross sectional design of this study, the feeding practice of children younger than 6 months, was only documented up to the time of measurement. This is in contrast with the MGRS, where the feeding practice of all children younger than 2 years of age, was documented over the whole trajectory. While this could affect the composition of the target group, any consequences on the growth of breastfed children between birth and 6 months can not be due to breastfeeding per se.

The average length is larger for Norwegian children but relatively comparable for Belgian children when compared with the WHO growth standards, although these differences tend to disappear by 3 years of age. The proportion of children below -2 SD was nevertheless considerably smaller than expected. A comparable pattern of average growth in length was also observed in the Norwegian sample of the WHO standards^{5 7}, which suggests a possible population effect.

In the case of BMI, adoption of the WHO growth standards would lead to a lower prevalence of underweight and an increased prevalence of overweight in Belgium and Norway. A comparable observation was made in the UK by Wright et al.⁸, who saw this as a positive feature, partly because of the current increase in childhood overweight. This is however contradicted by the observation in our study that, compared to the WHO growth standards, weight and BMI in breastfed children is broadly comparable to that of all children. Any comparisons with the WHO standards for weight and BMI are nevertheless limited by the fact that the WHO did not publish site differences for these traits¹⁵. Comparable results were obtained when plotting SD scores of weight for length/height (data not shown).

The most striking differences were observed for head circumference. When applied in Belgium or Norway, the proportion below -2 SD of the WHO growth standards was less than

half the expected amount (only 8% of the expected number in Norway); approximately 70% of all children are above the median (data not shown); and the proportion above +2 SD would increase up to three-fold. In Norway, in each annual birth cohort of approximately 60,000 children about 4,000 would be above the 97th percentile (expected 1,500), and only about 100 would be located below the 3rd percentile (expected 1,500). Although clinical guidelines for head circumference are seldom based on a single measurement, clinicians and medical staff of well baby clinics and school health centres would find a very high proportion of their population with large heads, while small heads would be virtually non-existing. This might lead to a large uncertainty concerning referral criteria, unwarranted examinations of many children and introduce unnecessary worries in many parents.

One of the main reasons for constructing the WHO growth standards was the observation that breastfed children grow differently from the previous NCHS/WHO international growth references, with faster growth in length and weight during the first six months, and slower growth thereafter¹⁶. A tendency towards this pattern was observed in the present study, although the general trend was more alike that of the local reference population. In our opinion, the present observations do not favour the use of the WHO growth standards for monitoring growth of children of Belgian or Norwegian origin, a result that may also be generalizable to other North/West European populations. The WHO growth standards are nevertheless a valuable instrument, (a) as an independent platform for international comparisons, and (b) as a tool for growth monitoring when a suitable local reference is unavailable, although differences in growth should be accounted for. Moreover, the concept of the WHO growth study has put breastfed children forward as the "norm", rather than the other way round, a view that we fully support.

In conclusion, we have demonstrated a significant deviation in the proportion of Belgian and Norwegian children that are located outside the normal limits for length/height, weight, BMI and head circumference of the WHO growth standards. Consequently, the implementation of the WHO growth standards would have unwanted clinical implications that are not supported by this study. This suggests that at least in Belgium and Norway, the use of a local reference based on a representative sample of healthy children, is more appropriate for all children, bottle fed or breastfed.

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Competing interests: None.

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What is already known on this topic:

- In 2006 the World Health Organisation (WHO) issued growth standards showing children's growth under optimal conditions
- The WHO advises universal use of these standards

What this study adds:

- The growth of Belgian and Norwegian children deviates significantly from the WHO growth standards, even when they are breastfed according to recommendations
- Head circumference is in both countries systematically 0.5 SD or more above the WHO growth standard

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Figure legends

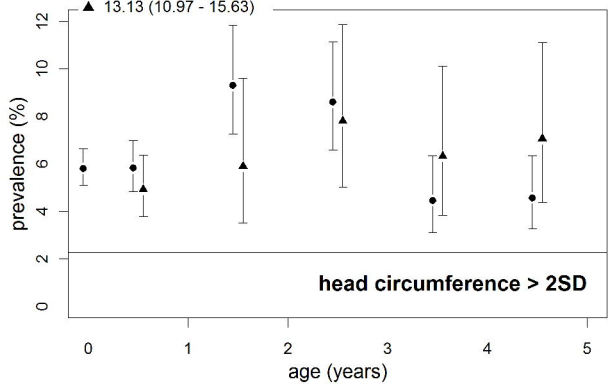
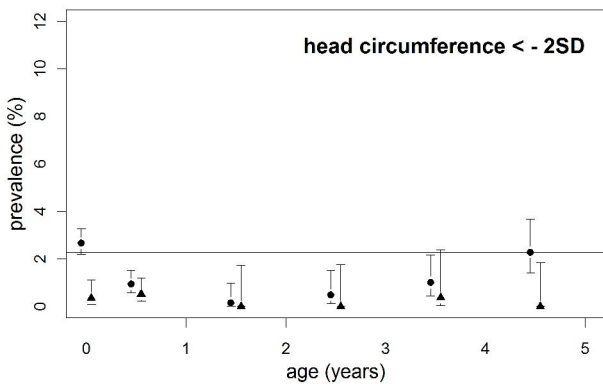
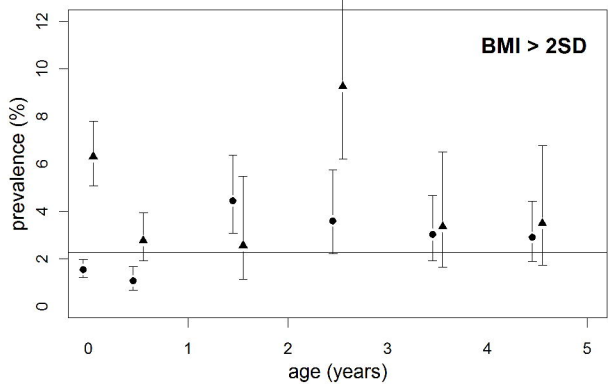
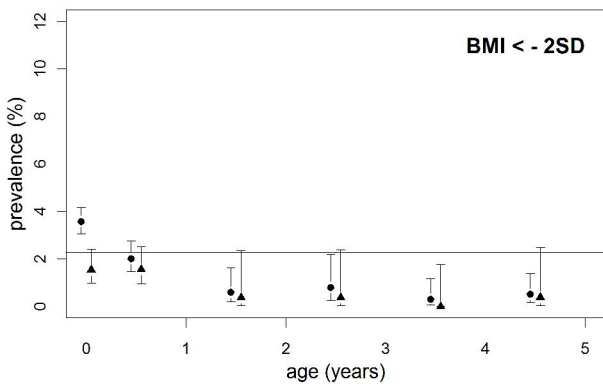
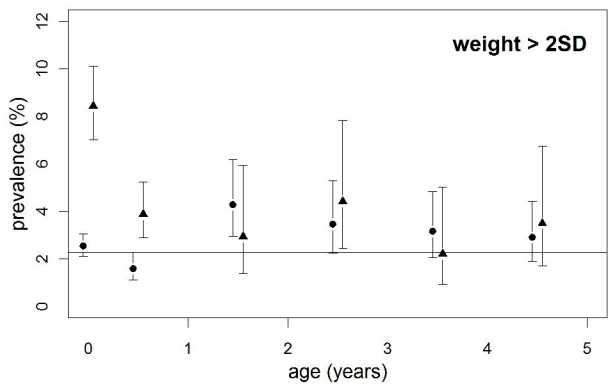
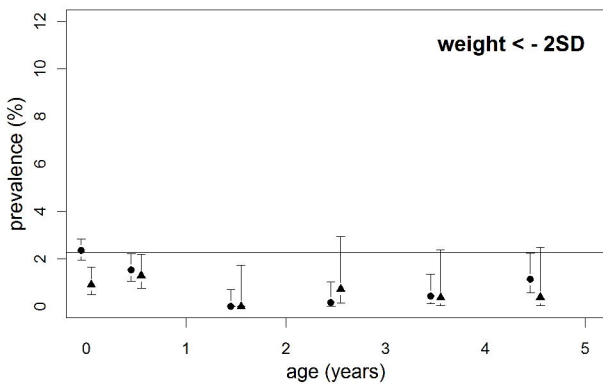
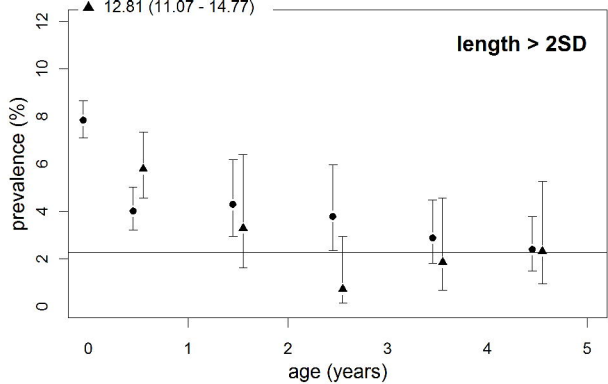
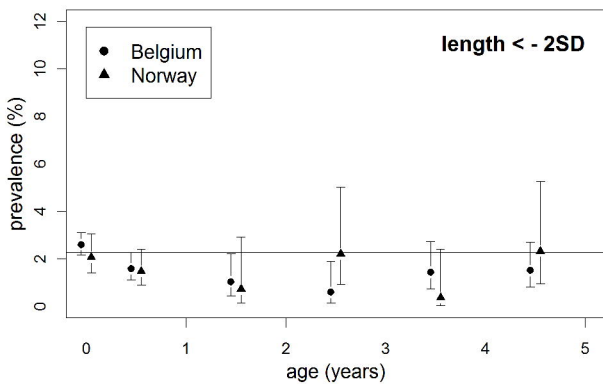
Figure 1. Percentage (95% confidence interval) of observations below -2 SD (left panels) or above +2 SD (right panels) of the WHO growth standards, in Belgium (●) and Norway (▲). Data are grouped by calendar age and plotted half way the interval. Birth data are analyzed separately and plotted at 0 years. Horizontal lines indicate the expected prevalence of 2.3 percentiles. Prevalence higher than 12% is marked at the top of the figure.

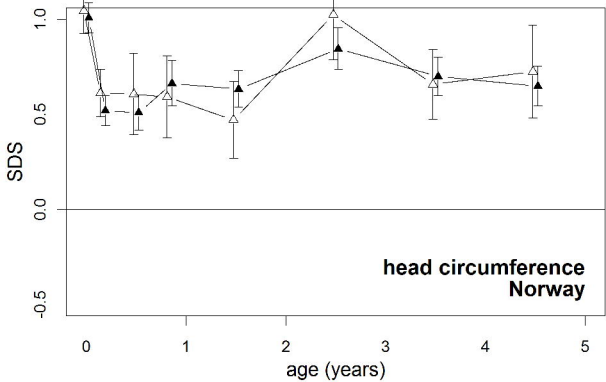
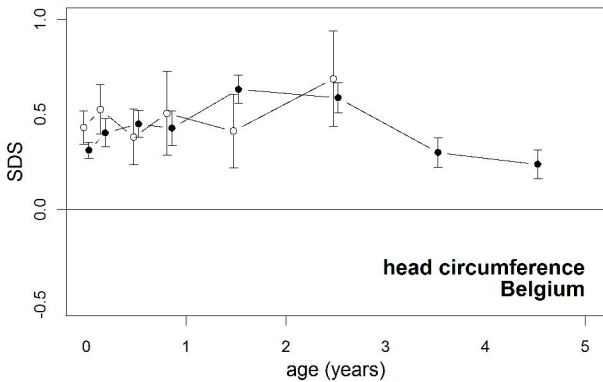
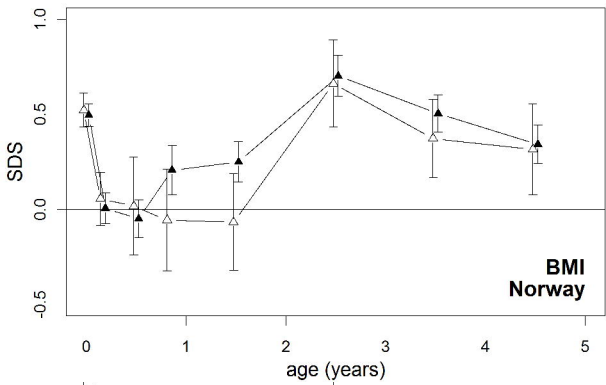
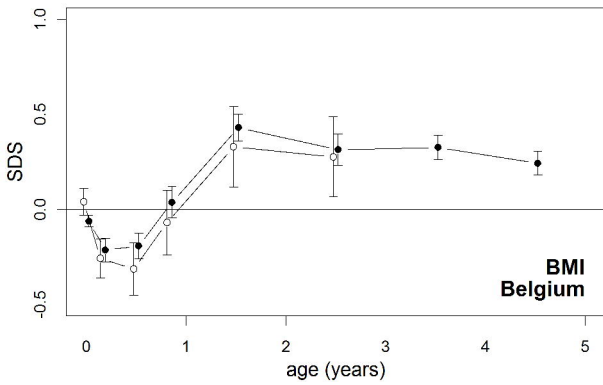
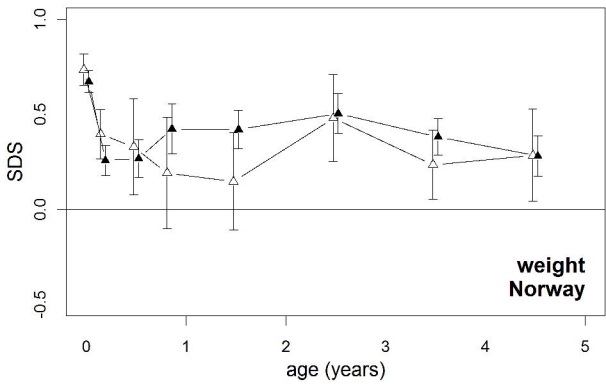
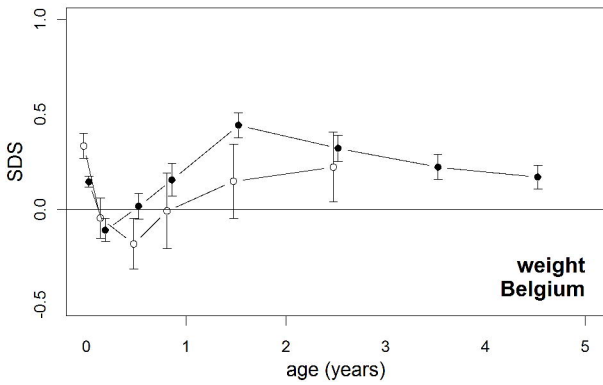
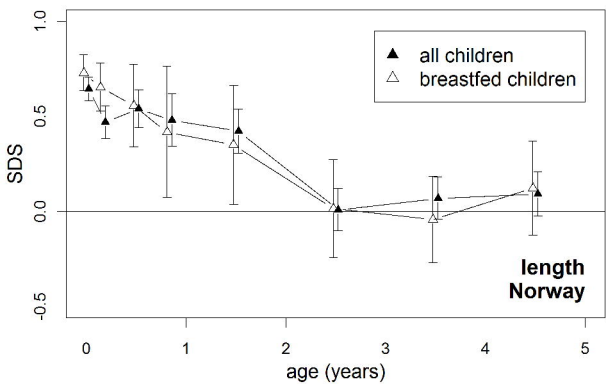
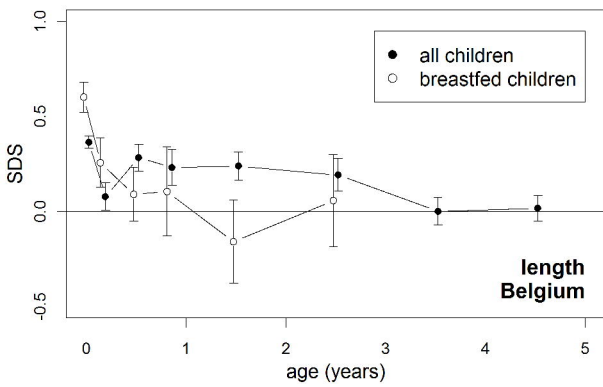
Figure 2. Mean SDS based on WHO growth standards from birth to 5 years of age for all children (○/△) and children breastfed according to the WHO recommendations (●/▲) in Belgium (left) and Norway (right). Observations are grouped per 4 months the first year, and yearly thereafter. Error bars represent 95% confidence limits of the mean.

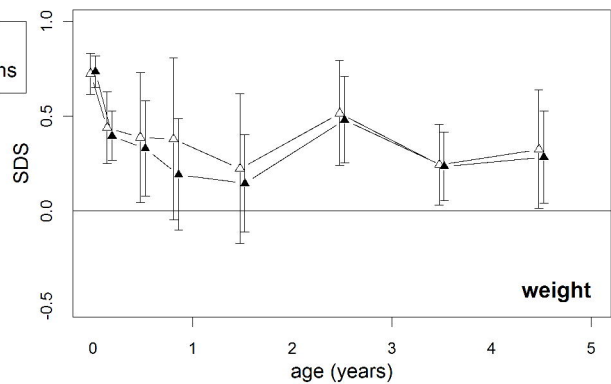
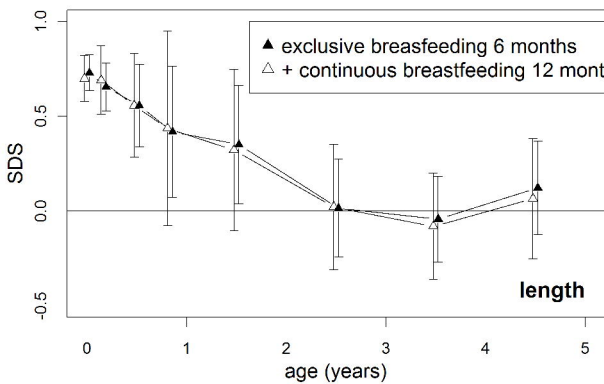
Figure 3. Mean SDS of children exclusively breastfed for at least 6 months (▲) and children that also received continuous partial breastfeeding up to at least 12 months of age (△) in the Norwegian sample. Error bars represent 95% confidence limits of the mean.

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