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REGULAR ARTICLE

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Norwegian children and adolescents in blended families are at risk of larger one-year BMI increments

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Abstract

Aim: To study how sociodemographic factors and family structure associate with baseline BMI z-scores (BMIz) and BMIz change in 767 Norwegian children aged 6-15 years.

Methods: Baseline BMIz and 1-year BMIz increments in children from the Bergen Growth Study were analysed with linear and logistic regression, according to sociodemographic factors and family structure. A blended family was defined as including a step-parent and/or half-sibling.

Results: In a fully adjusted regression model, baseline BMIz were only significantly associated with maternal BMI (b = 0.087, 95%CI 0.067, 0.107). Body Mass Index z-scores increments were larger in children living in a blended family (b = 0.060, 95%CI 0.006, 0.115), with a lower parental education (b = 0.127, 95%CI 0.029, 0.226) and with a higher maternal BMI (b = 0.008, 95%CI 0.001, 0.014). The odds for a large BMIz increment (>1 SD) were higher in children living in blended families (OR 1.82, 95%CI 1.16, 2.88) and with higher maternal BMI (OR 1.07, 95%CI 1.01, 1.13) and lower in 9-11-year-old children (OR 0.44, 95%CI 0.26, 0.77) compared with 12-15-year-olds.

Conclusion: Body Mass Index z-scores increments were more strongly associated with sociodemographic factors and living in a blended family than baseline BMIz values. BMI z-scores increments could be useful for identifying children at risk of becoming overweight or obese.

KEYWORDS
BMI, divorce, family type, maternal factors, overweight

1 | INTRODUCTION

The causes of the childhood obesity epidemic are multifactorial and include a lifestyle with unhealthy eating habits[1] and more sedentary behaviour.[2] However, the child's family and social situation have also been found to be important, with low parental educational level,[3] high parental BMI [4] and family break-up [5] as known factors that are associated with overweight. Moreover, children that have experienced divorce, or children living with step-parents, are more prone to have problems in the domains of academic achievement, psychological well-being, self-esteem, and peer relations and frequently have weaker emotional bonds with their parents.[6]

About 50% of children of married parents experience family break-up before reaching the age of 18 years, making this a

Abbreviations: BMI, body mass index; BMI increments, increase in BMI; Blended family, a family including a step-parent and/or half-siblings; IOTF, international obesity taskforce; OR, odds ratio; SD, standard deviation; 95%CI, 95% confidence interval.

frequent childhood stressor.[7] Cohabiting parents, representing about 50% of parents in Norway, split up at twice the rate of married parents,[7,8] but only a few studies have included cohabiting parents' break-up in addition to divorce and the blended family structure as a stressor.[9,10] In most studies, these families are categorised as single-parent families, although the child's life could be very different in a blended family with a step-parent and/or half-siblings.[6]

The objective of our study was to investigate the effect of sociodemographic factors and family structure on the BMI and 1-year BMI increments in children aged 5.5-15 years. We hypothesised that children living in single parent or blended families are at risk for larger 1-year BMI increments.

Key notes

- Body mass index (BMI) z-score increments could be useful to identify children with an ongoing risk of developing overweight.
- Maternal BMI and parental education were associated with larger 1-year BMI increments.
- One-year BMI increments were also larger in children living in blended families.

2 | METHODS

2.1 | Study population

The Bergen Growth Study (BGS) is a mixed longitudinal study, with follow-up measurements 1 year after the baseline measurement in a subset of school-aged children, allowing the study of BMI increments.[11] A total of 8299 children aged 0-19 years were recruited and measured between November 2003 and December 2006 in a random selection of 34 days care centres and 19 schools in Bergen country.[12] In a subsample of seven schools, children were invited for a second measurement after 12 months (plus/minus 1 month), between October 2005 and March 2006. Anthropometric data were available at baseline and at 1-year follow-up in 1209 children. The parental questionnaire was distributed in August 2006 and a reminder was sent in January 2007. The response rate for the parental questionnaire was 67%, but somewhat lower in the children above 12 years of age (53%).[12] About half of the questionnaires were returned by September 2006, and 97% by March 2007. For the present analysis, we included 767 children for whom the parental questionnaire was returned, excluding 15 children with a disease that could affect growth, three with a second measurement before 11 months or after 13 months, 19 children with an age outside of the range of 5.5-15 years, and two children with incomplete data for BMIz at baseline.

2.2 | Anthropometric measurements/BMI increments

Height and weight were measured by trained healthcare workers using a standardised technique, as described previously.[12] The BMI was calculated as weight divided by height squared (kg/m^2) and converted to BMI z-scores (BMIz) based on the national BMI reference.[12] A BMIz increment was defined as the difference between BMIz after 1 year and BMIz at baseline, not adjusted for the time interval. A positive BMIz increment was defined as a higher BMIz after 1 year than at baseline. Weight status (normal weight, overweight, obesity) was determined by the IOTF criteria [13] at baseline and after 1 year. Overweight includes obesity, and normal weight includes underweight throughout the text. Mother's and father's BMI were calculated from self-reported height and weight.

2.3 | Questionnaire

The parental questionnaire contained items on the sociodemographic background and family structure. The parental educational level was classified as low (primary school; <12 years of education), medium (secondary school; 12 years of education) and high (higher education; more than 12 years of education). We used maternal BMI rather than paternal or mean parental BMI since the BMI of the mother is more closely correlated with childhood overweight,[4] and less often missing (6.6%) than paternal BMI (15.9%). Family structure was categorised in three groups: blended families, defined by the

TABLE 1 Descriptive statistics of children from the Bergen Growth Study included in the present analysis

	Number (% or SD) N = 767
IOTF at baseline (%) (n = 767)	
Normal BMI and underweight	640 (83.4%)
Overweight/obese	127 (16.6%)
Mean baseline BMIz (SD)	0.01 (1.03)
Mean BMI z-score after 1 y (SD)	0.04 (1.03)
BMIz increments (n = 767)	
Mean increments[a] (SD)	0.03 (0.32)
N with BMIz increase (%)	424 (55.3%)
N with BMIz decrease or stable (%)	343 (45.5%)
BMIz increments above +1 SD[b] (%)	125 (16.3%)
Normal BMI and underweight	112 (14.6%)
Overweight/obese	13 (1.7%)
Parental BMI >25 (%) (n = 581)	
Maternal BMI >25	234 (40.3%)
Paternal BMI >25	382 (65.8%)
Both parents BMI >25	149 (25.7%)

Abbreviations: BMIz, BMI z-score; N, number; SD, standard deviation; y, years.
[a]Paired *t* test 0.33 (0.001-0.06).
[b]>+1 SD corresponds to >0.32 BMIz in our dataset.

presence of a step-parent and/or half-sibling(s), single-parent families and nuclear families.

The prevalence of overweight was lower in children who answered the questionnaire (10.6%) compared to those who did not (12.6%), which is a statistically significant difference ($P = .003$; chi-squared test for independence), but with a small effect size (Cramer's V: 0.05).

2.4 | Statistical analysis

Baseline BMIz and BMIz increments were analysed with linear regression models according to sociodemographic and family factors. Models for BMIz increments were adjusted for baseline BMIz to correct for regression to the mean. Baseline BMIz and maternal BMI were entered into the models as continuous variables, and the other variables as categorical. Results are presented for partially adjusted models (adjusted only for baseline BMIz) and fully adjusted regression models. Relevant interactions were tested and added if statistically significant. The Levene test of equality of error variances was significant, which could indicate that linear regression was not the best option, but the difference in variance was not large and visual inspection of residual plots showed only limited heteroscedasticity. We therefore chose to keep the linear models, which can be interpreted as (confounder) adjusted mean differences between groups. Results of the linear regression analyses are reported as unstandardised regression coefficients (B) that express the effect on the original measurement scale (eg maternal BMI) with a 95% confidence interval (CI). For independent variables with more than two categories (eg age groups), B is a measure of the mean difference between one level and the reference category. Logistic regression was used to examine the association between family structure and large BMIz increments, taking other sociodemographic factors into account. A large BMIz increment was defined as >1 SD, which corresponds to a change in BMI z-score between baseline and follow-up of 0.32 units. Results are expressed as odds ratios with corresponding 95% confidence intervals (CI).

Changes in mean increments and differences in BMI increments between children with normal weight or overweight were analysed with *t* tests, and the prevalence of a high parental BMI in children with normal weight or with overweight was analysed with a chi-squared test.

A *P*-value of .05 or less was considered statistically significant. The data were analysed using SPSS 24.0.

3 | RESULTS

The prevalence of overweight and obesity according to the criteria of the International Obesity Taskforce (IOTF) [13] was 12.5% and 4.0%, respectively, at baseline and 15.2% and 2.6% after 1 year (chi-square $P < .001$). There were only few children with obesity in our study group (n = 31), and none in the oldest age group (12-15 years) (Table 1). A majority of parents (64%) had a higher educational level, and 29%

TABLE 2 Linear regression of five sociodemographic and family variables on BMI z-score at baseline; 2 models: unadjusted and adjusted. No significant interactions

		BMIz at baseline			
		Unadjusted (N = 701)		Fully adjusted (N = 701)	
	N = 767 (%)	B	95% CI	B	95% CI
Boys vs girls	373 (48.6%)	−0.061	−0.207; 0.086	−0.470	−0.192; 0.097
Age groups					
5.5-8 y	327 (42.7%)	0.108	−0.078; 0.294	0.124	−0.061; 0.308
9-11 y	253 (33.1%)	0.056	−0.140; 0.252	0.079	−0.115; 0.273
12-15 y	185 (24.2%)	Ref.			
Parental education					
Primary school	57 (7.5%)	−0.209	−0.509; 0.092	−0.118	−0.424; 0.188
Secondary school (12 y)	219 (28.7%)	0	Ref.	0	Ref.
Higher education	487 (63.8%)	−0.182	−0.346; −0.018[a]	−0.129	−0.292; 0.034
Maternal BMI	581 (75.8%)	0.090	0.071; 0.110[a]	0.087	0.067; 0.107[a]
Family structure					
Blended family	196 (25.9%)	0.023	−0.148; 0.194	0.007	−0.162; 0.177
Single parent	61 (8.1%)	−0.060	−0.335; 0.215	0.000	−0.269; 0.268
Nuclear family	500 (66.1%)	Ref.			

Note: Blended family: the presence of a step-parent and/or half-siblings.
Abbreviations: BMIz, BMI z-score; N, number; SD, standard deviation; Y, years.
[a]Significant at 0.05 level.

TABLE 3 Linear regression of five sociodemographic and family variables on BMI z-score increments after 1 year; 2 models: adjusted for baseline BMI z-score and fully adjusted. No significant interactions

		BMIz increments			
		Adjusted for baseline BMIz N = 767		Fully adjusted N = 701	
	N = 767 (%)	B	95% CI	B	95% CI
Baseline BMIz	767 (100%)	−0.109	−0.138; −0.079[a]	−0.053	−0.077; −0.028[a]
Boys vs girls	373 (48.6%)	0.014	−0.032; 0.060	−0.002	−0.049; 0.045
Age groups					
5.5-8 y	327 (42.7%)	0.029	−0.030; 0.088	0.005	−0.055; 0.064
9-11 y	253 (33.1%)	−0.024	−0.085; 0.038	−0.041	−0.103; 0.022
12-15 y	185 (24.2%)	Ref.		Ref.	
Parental education					
Primary school	57 (7.5%)	0.109	0.016; 0.202[a]	0.127	0.029; 0.226[a]
Secondary school (12 y)	219 (28.7%)	0	Ref.	0	Ref.
Higher education	487 (63.8%)	0.027	−0.024; 0.078	0.042	−0.011; 0.095
Maternal BMI	581 (75.8%)	0.008	0.002; 0.015[a]	0.008	0.001; 0.014[a]
Family structure					
Blended family	196 (25.9%)	0.070	0.017; 0.124[a]	0.060	0.006; 0.115[a]
Single parent	61 (8.1%)	0.005	−0.080; 0.091	0.019	−0.067; 0.106
Nuclear family	500 (66.1%)	Ref.		Ref.	

Note: Blended family: the presence of a step-parent and/or half-siblings.
Abbreviations: BMIz, BMI z-score; N, number; SD, standard deviation; Y, years.
[a]Significant at 0.05 level.

had completed secondary school. In this sample, 11.2% of the children had at least one parent originating from outside of Norway.

Body Mass Index z-score increments were smaller in children with overweight (−0.05 ± 0.30) than in children with normal weight (0.05 ± 0.32), (*t* test $P < .001$). The BMIz increased (positive increment) in a total of 424 children (55.3%) (Table 1), of whom 13% were children with overweight and 87% were children with a normal weight at baseline.

Both parents had a BMI above 25 in 46% of children with overweight at baseline, compared to 17% in children with normal weight. Maternal overweight was present in 58% of children with overweight compared to 28% in children with a normal weight. Paternal overweight was present in 81% and 55% of children, respectively (chi-square $P < .001$ for all). The overall prevalence is presented in Table 1.

One in four children lived in a blended family (n = 196, 26%), 61 (8%) in a single-parent family, 500 (66%) in a nuclear family and 10 (1%) in another type of family (7 of them with grandparents) (Table 2). Out of the 70 children (9%) living with a step-parent, 64 (91%) lived with a step-father. In 52 families (7%), the child lived with both a step-parent and half-siblings, and in 126 families (16%) the child had half-siblings, but did not live with a step-parent.

3.1 | BMIz at baseline

In the unadjusted linear regression models, a high parental education was associated with lower baseline BMIz whereas higher maternal BMI was associated with higher baseline BMIz (Table 2). In the fully adjusted linear regression model, only maternal BMI was associated with higher baseline BMIz (Table 2).

3.2 | BMIz increments after 1 year

Baseline BMIz were associated with lower BMIz increments (Table 3). A low parental education, high maternal BMI and a living in a blended family were associated with larger BMIz increments in both partially (adjusted for baseline BMIz only) and fully adjusted linear regression models (Table 3).

3.3 | Large (>1 SD) BMIz increments (logistic regression)

A high baseline BMI was associated with lower BMIz increments and vice versa. The odds for a large BMIz increment were also lower in children aged 9-11 years compared with children aged 12-15 years, and higher in the presence of a high maternal BMI and in children living in a blended family in both partially (adjusted for baseline BMIz) and fully adjusted logistic regression models (Table 4).

3.4 | Interpretation of results

For a boy aged 15 and living in a blended family (b = 0.06, Table 3), the BMI would increase with approximately 0.2 kg/m^2 over the course

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TABLE 4 Binary logistic regression of 5 sociodemographic and family variables on large BMIz increments (> +1 SD[b]), corrected for baseline BMI z-score. No significant interactions

		Binary logistic regression of BMIz >1 SD[b]			
		Adjusted for baseline BMIz		Fully adjusted	
		N = 767		N = 701	
	N = 767 (%)	OR	95% CI	OR	95% CI
Baseline BMIz	767 (100%)	0.71	0.59; 0.86[a]	0.65	0.52; 0.81[a]
Boys vs girls	373 (48.6%)	1.25	0.85; 1.84	1.34	0.89; 2.03
Age groups					
5.5-8 y	327 (42.7%)	0.65	0.41; 1.02	0.67	0.41; 1.09
9-11 y	253 (33.1%)	0.43	0.25; 0.72[a]	0.44	0.26; 0.77[a]
12-15 y	185 (24.2%)	1	Ref.	1	Ref.
Parental education					
Primary school	57 (7.5%)	1.62	0.78; 3.38	1.80	0.79; 4.08
Secondary school (12 y)	219 (28.7%)	1	Ref.	1	Ref.
Higher education	487 (63.8%)	1.07	0.68; 1.68	1.20	0.74; 1.94
Maternal BMI	581 (75.8%)	1.07	1.01; 1.13[a]	1.07	1.01; 1.13[a]
Family structure					
Blended family	196 (25.9%)	1.93	1.26; 2.96[a]	1.82	1.16; 2.88[a]
Single parent	61 (8.1%)	1.59	0.80; 3.16	1.67	0.83; 3.38
Nuclear family	500 (66.1%)	1	Ref.	1	Ref.

Note: Blended family: the presence of a step-parent and/or half-siblings.
Abbreviations: BMIz, BMI z-score; N, number; SD, standard deviation; Y, years.
[a]Significant at 0.05 level.
[b]>+1 SD corresponds to >0.32 BMIz in our dataset.

of 1 year (BMI SD in boys aged 16 is 2.6 in our material), which corresponds to a surplus increase in body weight of about 0.6 kg. While this gain may appear small, so is that of other well-known risk factors to which it should be added.

4 | DISCUSSION

In the present study, 1-year BMIz increments and large (>1 SD) BMIz increments were associated with parental education, maternal BMI and living in a blended family. Baseline BMIz was also associated with parental education and maternal BMI, but not with family structure. To our knowledge, this is the first study to compare BMIz and BMIz increments in relation to family structure. Our study underlines the importance of follow-up measurements for the early identification of children at risk for an undesired weight development.

Body Mass Index z-score increments have been shown to be a good proxy for fat mass change in children.[14] An annual BMIz increment of 2 SD was suggested as a cut-off for identifying Japanese children at risk of obesity,[11] and a BMIz change of + 1 SD in childhood and adolescence was shown to predict higher fat mass in Swedish young adult men.[15] Identifying factors associated with weight increase in childhood could therefore be important in order to prevent childhood overweight.

A new finding of our study is the association between an ongoing increase in BMIz and living in a blended family. Family break-up is one of the stressors included in the adverse childhood events (ACEs) and is associated with childhood overweight.[16] ACEs have been related to childhood overweight [16-18] and overall poor health outcome, including obesity in adulthood.[19] The connection between family structure and childhood overweight could be mediated through both physiologic and lifestyle factors.[20] Children who have experienced parental break-up spend more time with screens,[5] drink more sugar-sweetened drinks,[21] and have more unhealthy eating habits, including the use of food for comfort.[5,21] Arkes found an increased risk of overweight 2 years prior to, and up to 6 years after a family break-up,[17] which could be the result of a parental conflict that may continue for years after the separation.[6,22] The presence of a step-parent could also be challenging for the child because of the inevitable adjustment to one or more new family members. Even though the presence of a step-parent usually results in an improved financial situation and parents may be able to spend more time with their children, it could also result in new rules and routines, or moving away from home, school or friends. In addition, the relationship with family members may become tense if the child experiences loyalty conflicts or a strained relationship with the step-parent.[6] Portrie [23] reviewed the literature on blended families and found that step-parents, and especially stepfathers, monitored stepchildren less closely than biological parents, which could have important implications regarding their lifestyle. Stepchildren tend to perceive discipline from step-parents as more harsh, which could raise conflict and introduce stress. In the end, especially cohabiting (ie not married) step-parents may have difficulties in finding their role in the family.[23] Children living in a blended family could thus be exposed to several risk factors for increased weight gain, if stress that results from adjusting to a new stepfamily is added to unhealthy lifestyle factors and stress related to family conflict.

In a Nordic study,[24] no association was found between family break-up and childhood overweight, but the authors concluded that this might have been due to selection bias because the response rate was very low. In a more recent study,[25] with an equally low response rate, no association was found between family break-up and cardio-metabolic risk factors in adolescence apart from smoking and alcohol consumption. Unfortunately, a low response rate might not occur at random,[26] and the risk of underestimating the association of risk factors with overweight is therefore real. While the overall response rate in our study was acceptable, the slightly lower prevalence of overweight in questionnaire respondents indicates that selection bias cannot be excluded, but it is probably small. The association between a blended family structure and BMIz increments in our study is small in terms of effect size, but as family break-up and a blended family structure are becoming more common, we believe this to be a risk factor that warrants further investigation.

In our study, we did not find any association between a single-parent family structure and BMIz increments. Children living with a single parent have earlier been reported to have higher BMIz and higher stress levels than those living in blended or nuclear families,[9,10] but these studies did not account for the presence of half-siblings which somewhat hampers the comparison with the single-parent category in our study.[24,27] A single-parent family could be the result of a divorce, but it could also result from the loss of a parent or simply be the original intended family context, and we therefore chose to keep this as a separate group. A blended family could be a different stressor than divorce,[28] as the child will have to adjust to new family members. Formisano [9] found that the presence of a step-parent was a protective factor compared to a single parent, but in our study there was no difference in BMIz at baseline or BMIz increments for the children living only with a step-parent and those also living with half-siblings (data not shown).

In our study, the child's sex or age was not associated to BMIz at baseline or BMIz increments, and in the logistic regression analysis of large BMIz increments, age, but not sex, was related. There was no interaction between the child's age and family structure in our data, which suggests that children were not more vulnerable at certain ages. This is in agreement with Dissing,[10] who found that age was unrelated to stress levels when studying divorce in children up to the age of 11 but contrary to Bzostek [29] who found that children aged 3 to 9 years were the most vulnerable to the negative effects of divorce in terms of behavioural problems. Unfortunately, we did not have information about the timing of the family break-up or the introduction of the stepfamily members which would have been an interesting addition regarding the timing of the unfavourable weight development.[6,17]

In accordance with other studies,[3,30] we found an association between parental educational level and the BMI in their offspring. A higher parental education was associated with a lower baseline BMIz, whereas a lower parental education was associated with larger BMIz increments. Furthermore, we observed a non-significant trend of increased risk for large BMIz increments in children of low-educated parents. The association between socioeconomic status and BMI could be mediated through lifestyle,[31] and parental education level is also linked to family structure [9] as there is generally a higher risk of separation among less-educated couples.[8]

Maternal BMI was found related both to baseline BMIz and to positive BMIz increments after a year in our study. While we found that both maternal and paternal BMI were associated with the BMI in offspring, only the maternal BMI was retained in the analysis to avoid the exclusion of children for whom no paternal data were available. The prevalence of maternal and paternal overweight in our data is comparable with the population prevalence at the time,[7] so our data seem reasonably representative in this respect.

There are some limitations to the present study. Children of parents with a high education level were over-represented in our study, about double compared to the national census estimate.[7] Families with shared parenting, about 10%-25% of children at this time,[7] are classified as nuclear families in our dataset, and this could lead to an underestimation of the association in the single-parent group. Other single parents are in the group of blended families, for example if the child has a half-sibling from a previous parental relation, but the parent currently is single. If we had information about step-siblings, we could have included more families in the blended family group. Also, we had no information about the time of break-up or the time of introduction of the step-parent. Finally, the parental BMI was calculated from self-reported height and weight. Strengths of the study are the longitudinal design, the relatively large number of otherwise healthy children with a wide age-range in the sample, and the fact that the questionnaire included more detailed information about blended families, when compared to many other studies, as we had information about step-parents and half-siblings. Moreover, we used a broad definition of family break-up by including blended families from cohabiting relationships (by using the variables step-parents and half-siblings), while other studies have used divorce ([5,9,27]).Therefore, the prevalence of family break-up in our data (26%) was much higher compared to a previous study in Norway (7%) which only included divorce,[27] but still below the expected prevalence of about 50%.[7]

The prevalence of overweight including obesity has been shown to increase from about 22% in children and adolescents to 60%-75% in adulthood, and that of obesity from about 7% in children to 20%-25% in adults.[32] Therefore, most future adults with overweight or obesity come from the group of children with a normal weight.[33] Body Mass Index z-score increments could be an important tool to identify children at risk for a gradual increase in weight. Combining this information with the sociodemographic and family background has the potential to further refine the search for children at risk, with the aim of prevention.[34]

5 | CONCLUSIONS

In the present study, we found that children living in a blended family as well as children with a high maternal BMI had larger BMIz increments, which should warrant attention in the preventive setting. BMIz increments allow us to monitor ongoing changes in weight and could be valuable to identify children at risk for developing overweight.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

ETHICAL APPROVAL

This study was approved by the Regional Committee for Medical Research Ethics (REK 2010/3276) and the Norwegian Data Inspectorate (9740). A signed informed consent was obtained from a parent or legal guardian of each participating child. For children above 12 years, informed assent was obtained by signature also from the child.

DATA AVAILABILITY STATEMENT

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