Childhood body mass index is associated with early dental development and eruption in a longitudinal sample from the Iowa Facial Growth Study

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KEY WORDS Childhood obesity, dental eruption, malocclusion

RUNNING TITLE BMI AND EARLY DENTAL DEVELOPMENT

Text: 12 pages; Bibliography: 5 pages; 6 tables; 8 figures

Grant sponsors: None

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Christina Nicholas assisted with project conceptualization, design, and write up and was responsible for data analysis. Kevan Kedavy assisted with project conceptualization, data collection and write up. Nathan Holton assisted with project conceptualization, design, and write up. Teresa Marshall assisted with project design and write up. Andrew Richter assisted with project design and data collection. Tom Southard assisted with project design and write up.

ABSTRACT

Introduction: High BMI (body mass index) children have been demonstrated to have precocious dental development. Existing work has largely focused on cross-sectional datasets, leaving an incomplete understanding of the longitudinal relationship between BMI and dental maturation.

Methods: We used a pure longitudinal growth series to examine the relationship between dental development and childhood BMI. Periapical radiographs from 77 children from the Iowa Growth Study were used to estimate dental development for subjects with known BMI.

Results: We confirm prior studies in finding that children with higher BMIs were more likely to have advanced dental development for their ages ($p<0.001$). BMI at age 4 was predictive of timing of dental development at age 12 ($p=0.052$). The precocity of the rate of dental development accelerated across growth. Overall dental development scores also correlated with age of dental eruption for the mandibular canines and first premolars ($p<0.001$).

Conclusions: High BMI at young ages is predictive of advanced dental development at later time points, suggesting a long-term effect of BMI on dental maturation, and implying the need for earlier orthodontic interventions in obese children. These results corroborate previous studies, building further evidence that relatively early dental eruption is another downstream consequence of childhood obesity.

Childhood obesity is a pressing national health concern, with upwards of 30% of United States children and adolescents estimated to be overweight or obese[1]. While the poor are statistically more likely to be overweight or obese[2-5], childhood obesity among all socio-economic groups has been on the rise[6-7] (but see Ogden et al.[1] for a discussion of how this trend has recently plateaued in some age groups). High BMI in childhood has many important health—and public health—implications, and researchers have asked the question: how does this influence dental development? Over the last decade, a number of studies have been published addressing this topic[8-17], and nearly all have found an association between being overweight or obese and having earlier tooth development (though not all studies have shown this difference to be clinically significant[16-17]). For example, in one of the first studies to investigate this topic, Hilgers et al.[8] found that being overweight was associated with an average of a year and a half of advancement in dental development, and being obese was shown to have a similar effect. These researchers also found that both males and females who were overweight or obese had precocious dental development; a result that has been corroborated by several other studies in different populations[13, 14, 18, 19]. Moreover, thin children were found to have the slowest rate of dental eruption while overweight children have the most advanced dental. This pattern exists as a gradient, where being "at risk" for being overweight (having a BMI at the upper extreme of scores in the "normal weight" range) implicated a more precocious dental development than those seen in the lower-average weight children. A high body mass itself may be influencing dental eruption directly (in terms of the fact that overall growth seems to be accelerated in obese children, including skeletal growth and age at first menarche in girls)[20], however, this is not the only possible explanation. It could be that factors that are caused by, or correlate with, obesity may be, at least partially, to blame.

A recent study[9] looked at diabetes, BMI, and dental eruption. Diabetes was found to be associated with earlier tooth eruption in the later stages of permanent tooth eruption (10-14 years of age). This study also looked at gingival inflammation. The researchers found that in both the control group and the case group, gingival inflammation was correlated with early tooth eruption (though not necessarily advanced tooth calcification)[9]. This demonstrates that the association between obesity and dental maturation may be correlative and not necessarily causative.

Many prior studies focus on dental eruption[9,10,13,21,22], in contrast to looking at dental development itself (but see Hilgers et al.[8]; Mack et al.[14]; Weddell et al.[16]). This is important because the actual biological pathway which is causing this early eruption is currently not known, and thus it is possible that early eruption may not indicate early development (i.e., teeth may be developing normally but erupting under-developed). It is currently unknown whether early dental eruption is associated with early dental development in obese children. While the evidence supporting the correlation between obesity and early eruption[8,14,16] would tend to make this possibility less likely, this has not been empirically tested. Of the studies which have looked at dental development[8-19,21-25] nearly all were cross-sectional, and therefore do not definitively address individual-level development of the teeth. The one exception to this is Sanchez-Perez et al.[10], which included multiple time points of dental eruption data (tooth counts) in a study of Mexican schoolchildren.

While there is a relationship between BMI and dental development/eruption, previous studies have largely focused on later ages groups. Given that the frequency of overweight/obese children across all age groups has increased over the past 40 years[2], it is vitally important to examine the relationship between body mass and dental development at younger ages. The purpose of the present study is to examine whether variation in body mass index has a longitudinal influence on dental development and the timing of dental eruption. We test the null hypothesis that childhood body mass index (BMI) is not statistically associated with timing of dental development and address the following research questions: 1) Does BMI influence dental development such that overweight individuals are characterized by precocious tooth development as seen in prior studies? 2) Is the effect of BMI on dental development static across growth? That is to say, can BMI at age 4 predict timing of dental development at later ages? 3) As a corollary, does an individual who has a given rate of dental development at one age have a similar rate (be it advanced, delayed, or normal) at later ages, regardless of BMI? 4) Are overweight individuals characterized by faster rates of tooth eruption (in contrast to tooth calcification)?

Prior studies have focused on either eruption or development (calcification) and have not resolved the possibility that high BMI children who erupt their teeth early may be erupting their teeth under-developed. In this study we combine dental developmental data and dental eruption data to test the hypothesis that they strongly covary in obese children, using data from a pure longitudinal growth series which included periapical radiographs (Iowa Growth Study). We further examine the relationship between dental development and timing of dental eruption in our sample to draw broader conclusions about the applicability of dental eruption data to questions about high BMI-associated developmental changes.

MATERIAL AND METHODS

Our sample consisted of n=77 children from the Iowa Growth Study. The University of Iowa conducted the Iowa Facial Growth Study from 1946 to 1960 and it is a pure longitudinal growth study. Study subjects entered the study between the ages of 3-5 years old and were followed continuously for the next 14 years. Full records were taken on the subjects every 3 months until age 5, every 6 months between the ages of 5 and 12 and then every year after age 12. Records taken include: health history, height, weight, alginate impressions from both arches, complete mouth series radiographs, lateral cephalometric radiographs and posteroanterior cephalometric radiographs[26].

To assess dental eruption we examined both periapical radiographs and posterior-anterior cephalograms for each subject. Dental development was scored by one observer (KK) from the periapical radiographs using the Demirjian et al.[27] method at approximately ages 4, 8, and 12. These age points were chosen as representative time points for fully deciduous dentition (age 4), early mixed dentition (age 8), and late mixed dentition (age 12). Using the Iowa Growth Study records, the observer was blinded to the BMIs of the subjects. The first ten individuals were rescored two weeks after their original scoring, and the agreement between the scores for each of the teeth was 0.97. Dental eruption was assessed for the mandibular left canines and first premolars, by viewing periapical radiographs and PA cephalograms for each subject and identifying the earliest age at which eruption was evident radiographically. We defined eruption as the apparent emergence of the tooth through the gingiva. We chose to estimate clinical eruption rather than alveolar eruption, despite the greater difficulty in visually assessing this on a radiograph, in order to make our data as comparable as possible to other studies. The mandibular canines and premolars were used because both typically erupt prior to our final time point, and variation in timing of the eruption of these teeth has been published on extensively in the literature[28-31]. Including both canines and first premolars also allows us to include both single- and multi-rooted teeth.

The Demirjian method[27] was used to assess dental development. This method provides for a quantitative assessment of dental maturation using dental calcification of the left quadrant of the mandibular teeth, incisors through the second molars. Each tooth is scored individually, and then a composite score for all teeth is summed and corresponds to an estimated dental age (in years) for each subject based on standards determined by Demirjian[27]. As the Demirjian method allows one to calculate an estimated Dental Age (DA) based upon development patterns, this can be compared with the child's actual Chronological Age (CA). We used the difference between CA and DA to calculated a metric we refer to as ΔAge.

We used documented height and weight data to calculate BMI at ages 4 and 12. Due to the fact that the study data was collected during the mid 20th century, prior to the current obesity crisis, we would not expect to find the same levels (or potentially magnitude) of obesity as would be seen in a more recent sample. However, the wealth of this longitudinal data would be difficult to replicate in a contemporary setting. BMIs values for each subject were categorized as underweight (below the 5th percentile), normal (5th-90th percentile), overweight (85th-95th percentile), or obese (above the 95th percentile)[31]. The BMI cut-offs by age and sex are listed below (Table 1). Because of the relatively small number of underweight and obese children, we chose to group children who were underweight at a given time point with their normal weight peers and overweight and obese were grouped together (Table 2).

[Insert Table 1, Table 2]

To examine the relationship between dental development and childhood BMI we ran a series of standard statistical tests using R[33]. To test our first research question, that high BMI is associated with accelerated dental development, we ran a linear regression on the aggregate dataset, and then separately on the Age 4, Age 8, and Age 12 data. For our second hypothesis, that BMI at younger ages would predict dental maturation at older ages, we regressed BMI at 4 on dental maturation at 8 and 12. To test our third hypothesis, regarding the longitudinal relationship between dental maturation and BMI, we used a grand-mean centered quadratic mixed effects model to assess change through time, using BMI at 4 as a predictor for ΔAge. Fourth and finally, we used Spearman's regression and Kruskal-Wallis rank sum tests to examine the relationship between dental eruption and dental maturation in our sample. For the longitudinal data, the Bonferroni correction factor was calculated as $\alpha<0.0167$ by dividing $\alpha<0.05$ by 3 for the three time points.

RESULTS

We found a low level of obesity in our sample (Table 2), as was to be expected given the population under study. Rates of precocious/early dental development varied based upon the calculation methods used, but were highest at age 12 and lowest at age 8 (Suppl. Table 1). The average age of eruption (in years) for the mandibular left canine was $\bar{x}$ =9.83 years (SD±0.95), and for the first premolar was $\bar{x}$=10.06 years (SD±1.0). The mean ΔAge for each time point in aggregate and by sex is shown in Table 3. We also calculated aggregate ΔAge for normal, overweight, and obese children at Age 4 (based on BMI at 4) and Age 12 (based on BMI at 12), shown in Table 4. At age 4, obese children are 0.57 years dentally advanced compared to normal weight children, and at age 12, they are 1.11 years dentally advanced (Table 4).

[Insert Tables 3-4]

BMI and timing of dental development

Our data was non-normally distributed (as determined by Shapiro-Wilk tests of normality), so we used non-parametric statistics. To test our first research question, whether high BMI is statistically related to advanced dental development, we ran a series of tests to examine the relationship between BMI and dental development. Firstly, we looked at the aggregate data (all age points), using $\alpha = 0.01667$ to correct for the effects of multiple testing. Body mass index was compared to ΔAge via linear regression. A statistically significant relationship was found for BMI at 4 and BMI at 12 ($p<0.001$, rho = 0.22; $p<0.001$, rho=0.25). This relationship held true when sex was accounted for using partial correlations analysis ($p<0.001$; $r=0.30$).

As there were likely to be differences in the relationship between dental development and BMI at the different age points, we broke our sample into subsets (4 years, 8 years, 12 years). Individuals who were missing radiographs at the exact ages studied (and, for example, had data at 5.0 but not 4.0) were excluded from these subsets.

At age 4, when BMI at 4 and ΔAge were compared there was a statistically significant relationship (*n*=69; p=0.0198, rho=0.28; Fig. 1).

[Insert Fig. 1]

Regressions of ΔAge at Age 8 on BMI at 4 and BMI at 12 were both statistically significantly correlated with dental advancement (*n*=75; p=0.013, rho=0.286; p=<0.001; rho=0.406; Fig. 2).

[Insert Fig. 2]

For the age 12 data, BMI at 12 was regressed on ΔAge, and was statistically significant (*n*=72; p=0.032, rho=0.269; Fig. 3).

[Insert Figure 3]

Can BMI at age 4 predict dental development at 8 and 12 years old?

For the Age 8 data, a regression of ΔAge on BMI at 4 was statistically significantly correlated with dental advancement (p=0.013, rho=0.286; Fig. 4). Body mass index at age 4 was also statistically significantly correlated with ΔAge at age 12 (p=0.012, rho=0.313; Fig. 5).

[Insert Figure 4]

[Insert Figure 5]

Longitudinal patterns of timing of dental development

We also examined the relationship between dental timing (as measured by ΔAge) at younger ages and at later ages. For example, if a patient is advanced in their dental development at Age 4, will they still be advanced at Age 8 or Age 12? On an individual level, it can be seen that most children in our sample saw an increase in dental advancement between the ages of 4 and 12 (Fig. 6a). In aggregate, the pattern was towards a decrease in ΔAge from 4-8 and an increase from 8-12, with an overall increase from 4-12 (Fig. 6b). When broken down by Normal BMI and High (overweight/obese) BMI, it can be seen that the overall trend is similar, with differences in the magnitude of dental advancement at all ages (Fig. 6c-d).

Since the relationship between time and dental development had both linear ($p<0.001$) and quadratic effects ($p<0.001$), we used a grand-mean centered quadratic mixed effects model to assess change through time. We used BMI at 4 as a predictor for ΔAge (Table 5).

[Insert Figure 6]

[Insert Table 5]

BMI and timing of dental eruption

To examine whether dental eruption correlated with dental development, we compared the estimated age of eruption for the mandibular canines and premolars with ∆Age in our Age 12 and Age 8 subsamples, further subdivided by sex.

To test whether advancement in dental eruption was associated with high BMI, variation in timing of eruption of the mandibular canines and first premolars between individuals who were normal weight and those who were overweight or obese was examined using a Kruskal-Wallis test. Due to known differences in timing of eruption between males and females, the data were subdivided by sex prior to analysis. For females, BMI at 12 (“normal” or “overweight/obese”) was associated with earlier eruption of the canines (p=0.01) and was approaching significance for the first premolars (p=0.10). However, BMI at 4 was not associated with age at eruption. In males, in contrast, neither BMI at 4 nor 12 was associated with timing of eruption of the canines (p=0.835; p=0.961) or first premolars (p=0.972; p=0.425).

The association between dental eruption and dental development (calcification)

When canine eruption age was regressed on ∆Age at 8, there was a highly significant, negative relationship in both females (p<0.001, rho=-0.756) and males (p<0.001; rho=-0.498; Fig. 7). This relationship was also found in the ∆Age at 12 sample (females: p<0.001, rho=-0.816; males: p<0.001, rho=-0.549). When premolar eruption age was regressed on ∆Age at 8, there was also a highly significant relationship for both females (p<0.001, rho=-0.698; Fig. 8) and males (p<0.001, rho=-0.422; Fig. 8). Again, this relationship was also found in the ∆Age at 12 sample (females: p<0.001, rho=-0.794; males: p<0.001, rho=-0.492). The relationship between dental eruption age and dental development held even when accounting for the effects of BMI via partial correlations analysis (for age 12, females: $p<0.001$ $r=-0.798$; males: $p<0.001$, $r=-0.579$).

[Insert Figure 7]

[Insert Figure 8]

DISCUSSION

Our results add to the growing body of literature which demonstrates a correlation between childhood BMI and early dental development. While there is still a high level of individual variation in timing of dental development, there is also a clear trend towards dental precocity in children who weigh more relative to their height. At Age 4, obese children are 5.7 months (more) advanced compared to normal weight children. By Age 12, this gap has grown to over a year (1.11). The longitudinal nature of our sample allows us to address the question: does high BMI in young childhood predict dental development timing much later in growth?

Our data tentatively support this hypothesis. Having a high BMI at 4 years old was statistically correlated with advanced dental development at 12 years old ($p=0.012$), and approaching significance at 8 years old ($p=0.013$). Given the very broad range of “normal” dental development at 8, we posit that give a large enough sample, this pattern would reach significance. We also see a decrease in average ΔAge at age 8 in our mixed model analysis; again, this decrease is at age 8 is likely an artifact of the huge range of inherent variation in timing of dental development at this age, rather than a meaningful slowdown of dental maturation.

When looking at our longitudinal data, we see that average dental advancement is again estimated at approximately 1.1 years (the intercept of our mixed effects model). The longitudinal interaction between BMI and ΔAge is moderate (0.099, p=0.052). This value indicates an 0.099 increase in ΔAge for every 1 unit increase in BMI; for a child with a BMI 5 units above average, this comes out to approximately half a year of advancement in dental development. While our results are only borderline significant (p=0.052), we think it particularly noteworthy that this trend can be seen in our sample given the small number of individuals with very high BMIs at 4 years old. However, the cross-sectional data on BMI at the age of examination (i.e., BMI at 12 and dental development at 12) presents a clearer picture of association at all age points, and provides further support for our longitudinal results. Thus it is not yet clear whether high BMI at young ages that is followed by a subsequent BMI reduction has the same effect as a high BMI throughout childhood. Nor what the relative impact of developing high BMI at a later age may be. Our small sample size has precluded us from investigating this question, and future research in this area is necessary.

It is important to note that despite clear secular changes in the timing of dental development[34], the overall pattern whereby heavier children are more likely to develop/erupt their teeth earlier apparently predates the current obesity epidemic.[35] There are many competing hypotheses for the origins of the demographic trends in BMI[29,36], some of which are predicated upon assumptions of patterns of behavior (e.g., energy-rich diets, bottle feeding, inactivity[36]) or environmental contaminant exposures (e.g., Bisphenol A)[37] which would have shifted between the time of the Iowa Growth Study and the dramatic rise in childhood obesity beginning in the 1980s. Thus while the obesity epidemic itself may have origins in a more recent environmental phenomenon, the effect of obesity on dental eruption is likely a long-standing human biological pattern.

We document here that early dental development is linked to early eruption in our sample, regardless of BMI. This would suggest that childhood obesity likely does not cause the eruption of underdeveloped teeth. This is a comforting conclusion, as teeth with shorter, underdeveloped roots might be less stable in the mouth. Future work is needed to confirm this result in a contemporary population with a higher incidence of childhood obesity. However, we tentatively posit that obese children with early eruption should be candidates for the same orthodontic treatment plans as non-obese children, with the caveat that the timing of intervention may need to occur at an earlier age, which is in line with the conclusions of similar studes[14].

What is still unknown is the mechanism for early eruption in obese children. A study of children with diabetes mellitus indicated that there is an association between early eruption and oral inflammation[9]. There is a documented relationship between obesity and inflammation[37], and it is possible that inflammation plays a role in the timing of tooth eruption for these patients. Another possible explanation would be changes in growth hormone levels (e.g., IGF-1). It is known that overweight/obese girls reach menarche at an earlier age[39]; interestingly, early menarche appears to also predict childhood obesity in the children of mothers who reached menarche at earlier ages[40]; early tooth development may be part of a suite of traits related to accelerated growth patterns in obese children. There is also little documentation of the effects of early eruption on other oral health outcomes, such as caries burden. Other researchers have posited that earlier development/eruption of teeth may lead to malocclusion, which might then lead to higher caries incidence[13]. Future research should investigate these hypotheses.

This research uses a valuable pure longitudinal growth studies to assess the interaction of BMI and timing of dental development across growth, using radiographic data. This type of analyses would be difficult to replicate in a contemporary sample, and thus provides unique insights into the nature of this relationship. However, there are clear limitations to our sample. The Iowa Growth Study is a Caucasian sample that is approximately half a century old with a limited number of subjects who were obese. An ideal sample would have had equal numbers of obese and normal-weight children, and greater racial/ethnic diversity. Our results may therefore be limited in their application to non-Caucasian groups. However, contemporary, cross-sectional studies of dental development and BMI have found precocious dental development in high BMI children of both Caucasian and African-American backgrounds[13,14]. Furthermore, despite the relatively small number of obese and overweight subjects in our sample, we still found the same general patterns of precocious dental maturation in high BMI children as have been documented in contemporary studies using cross-sectional dental development data8[,12,14,25] or longitudinal dental eruption data[10]. It is therefore still probable that our results are, broadly speaking, applicable to most contemporary groups.

CONCLUSIONS

The results of this study confirm a pattern that has been documented in the literature over the past decade, whereby overweight and obese children show precocious tooth eruption. This study adds the dimension of longitudinal data, showing that BMI at young ages may predispose a pattern of early dental development that persists across growth. A pattern of early development established at 4 typically sets a child up for reaching dental development milestones predictably early/delayed across later ages. This study also combines information on both dental development and the specific timing of tooth eruption. Furthermore, we show that precocious dental eruption is strongly tied to precocious dental development (calcification), potentially indicating that precocious eruption in obese children does not represent the eruption of underdeveloped teeth. An important caveat is that this is a Caucasian sample that is approximately 50 years old. However, our findings mirror those of other studies on contemporary populations, and add valuable longitudinal data that his often difficult to replicate in a modern clinical setting. Our results indicate that dental development may indeed be a part of a suite of developmental traits that are advanced in rate and/or timing in obese children, such as age at first menarche in girls. The trend observed in this study and others, whereby dental development is increasingly advanced, on average, at higher BMIs has important implications for pediatric dentistry, orthodontics, and anthropology. Orthodontic treatment may sometimes need to occur at earlier chronological ages, on average, in overweight and obese children than in their normal weight counterparts.

ACKNOWLEDGEMENTS

Our thanks to our three anonymous reviewers, whose feedback has measurably improved this manuscript.

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FIGURE LEGENDS

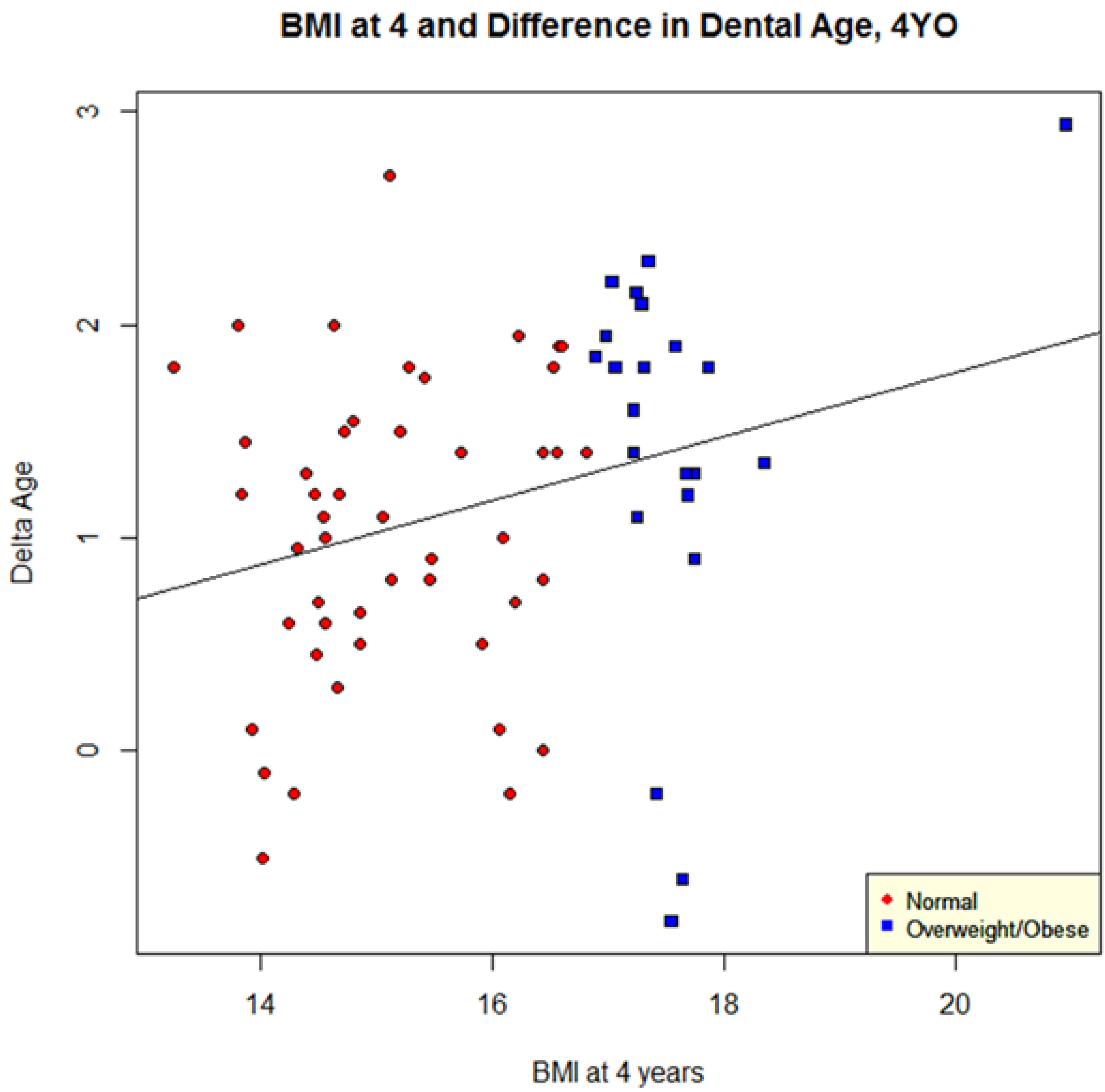

Figure 1. Scatterplot depicting the correlation between dental development and BMI. Individuals with earlier tooth development have higher BMIs than those with later tooth development.

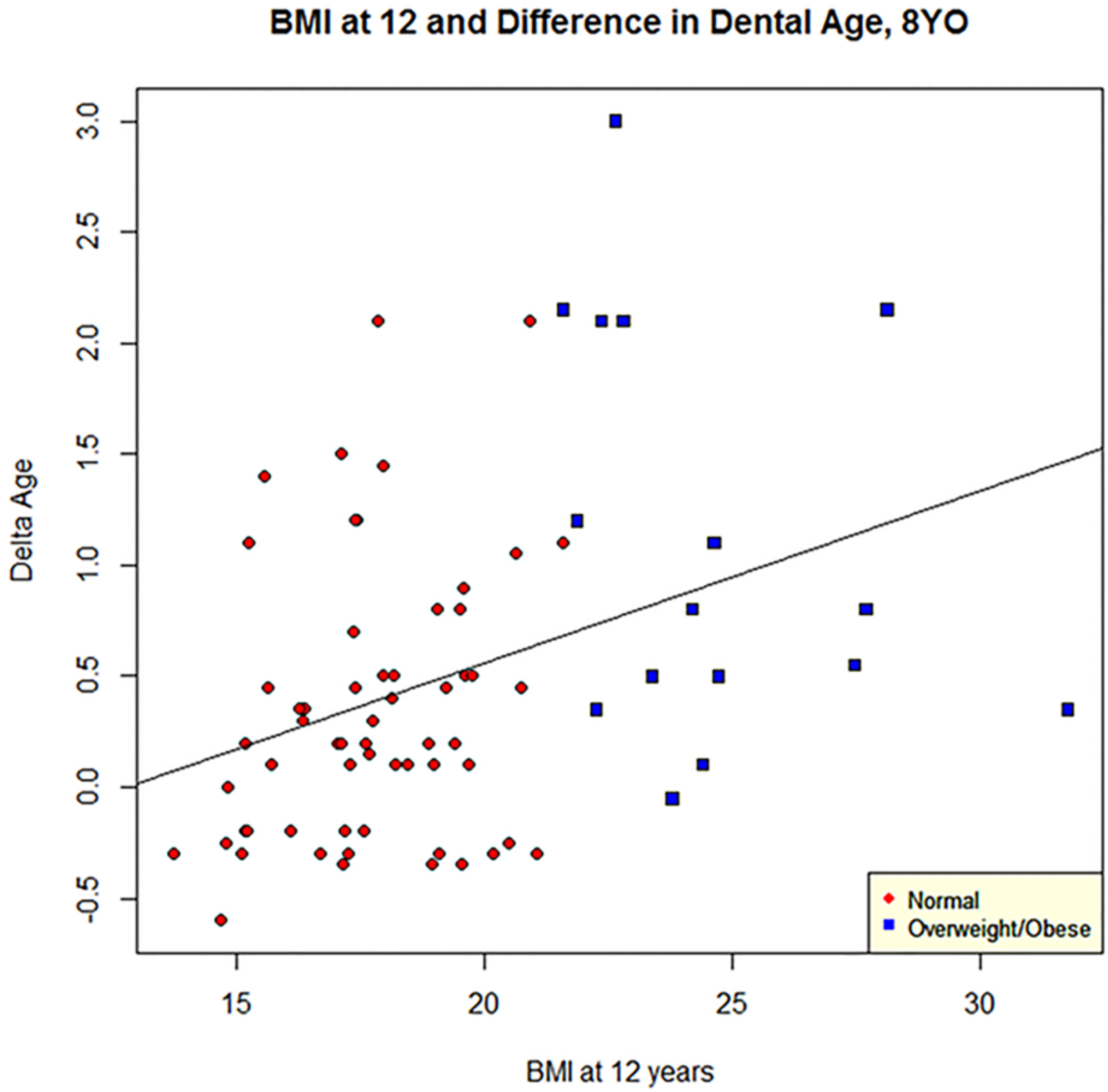

Figure 2. Scatterplot depicting the relationship between a child's BMI at 12 years of age and the ΔAge at 8 (in years), labelled by weight category. There is a broad range of variation within each weight category, but also a trend towards higher ΔAge scores (and thus, earlier dental development) among individuals with higher BMIs.

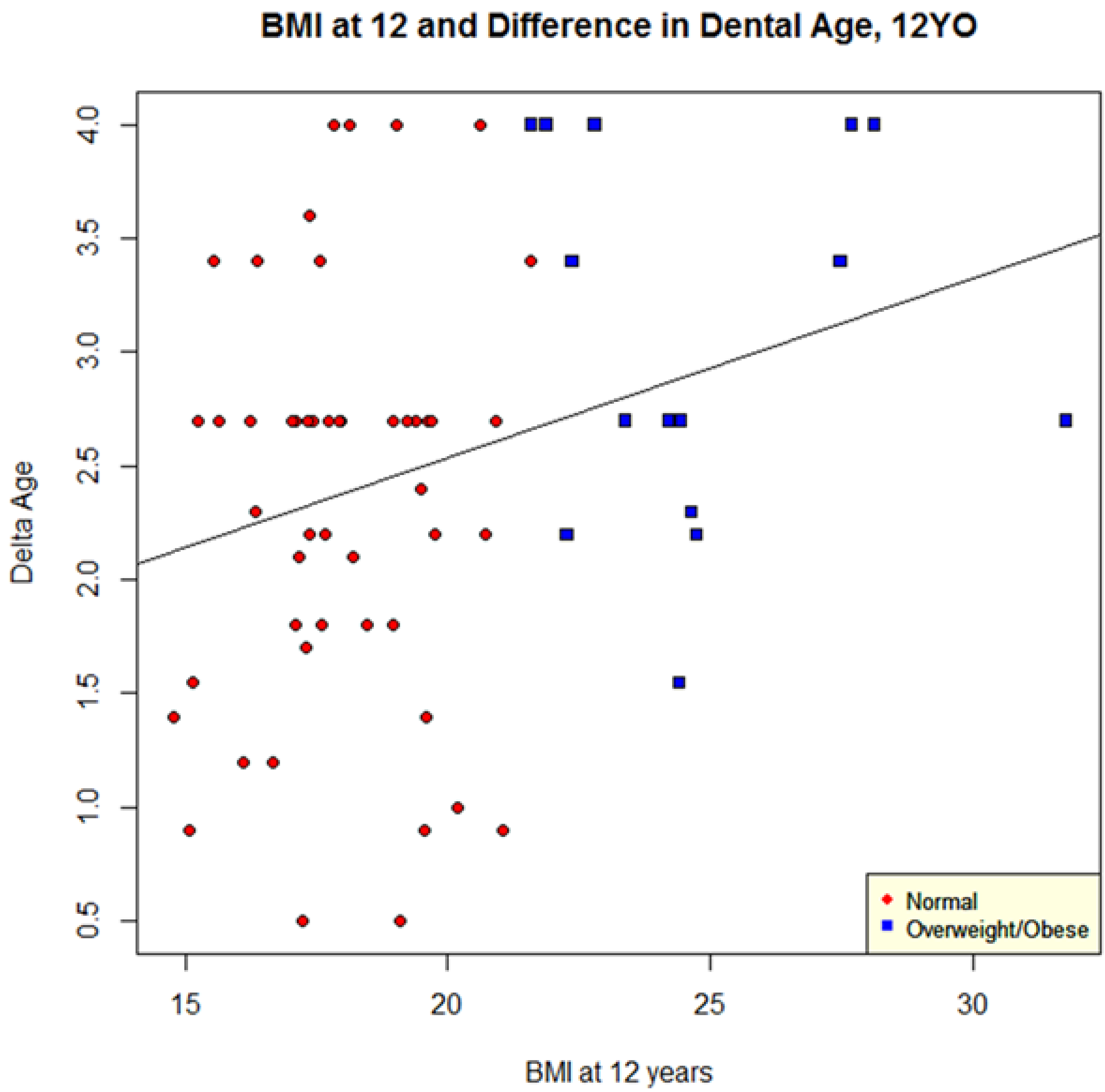

Figure 3. Scatterplot depicting the relationship between a child's BMI at 4 years of age and the ΔAge at 12 (in years), labelled by weight category. BMI at 12 years old is also correlated with precocious dental development at age 12.

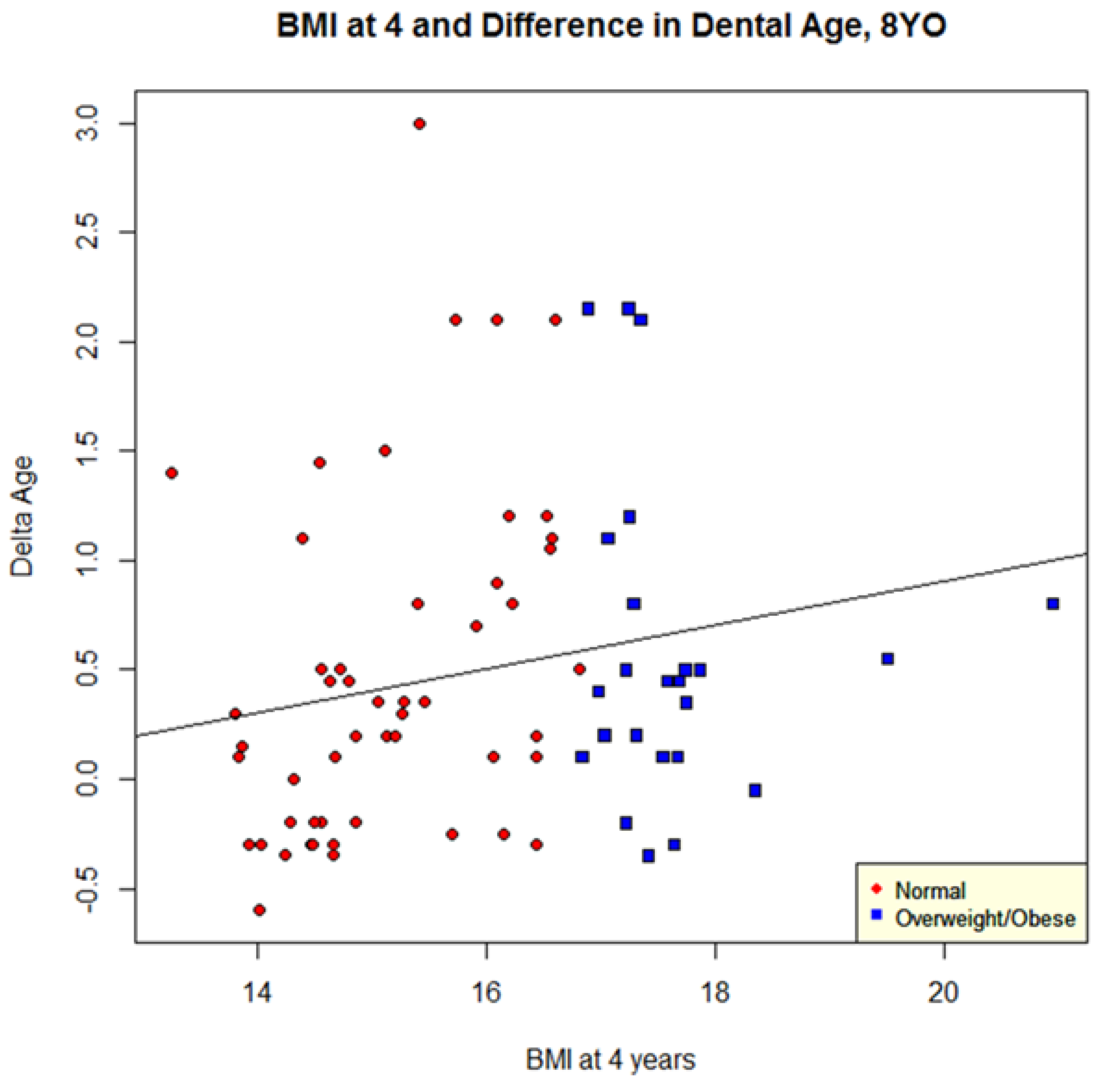

Figure 4. Scatterplot depicting the relationship between a child's BMI at 4 years of age and the ΔAge at 8 (in years), labelled by weight category. BMI at as young as 4 years old is correlated with precocious dental development at age 8.

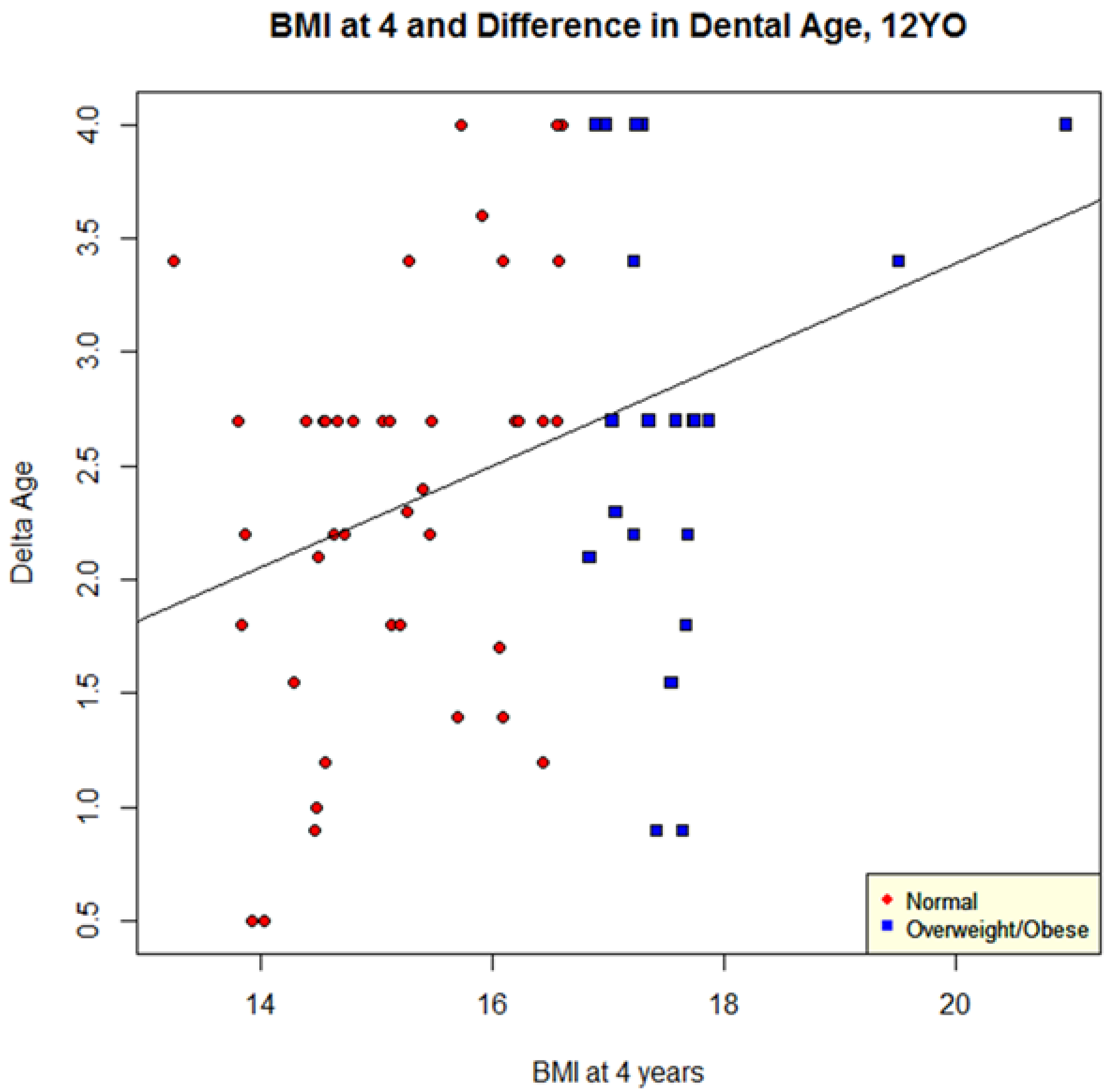

Figure 5. Scatterplot depicting the relationship between a child's BMI at 4 years of age and the ΔAge at 12 (in years), labelled by weight category. BMI at as young as 4 years old is correlated with dental development at age 12.

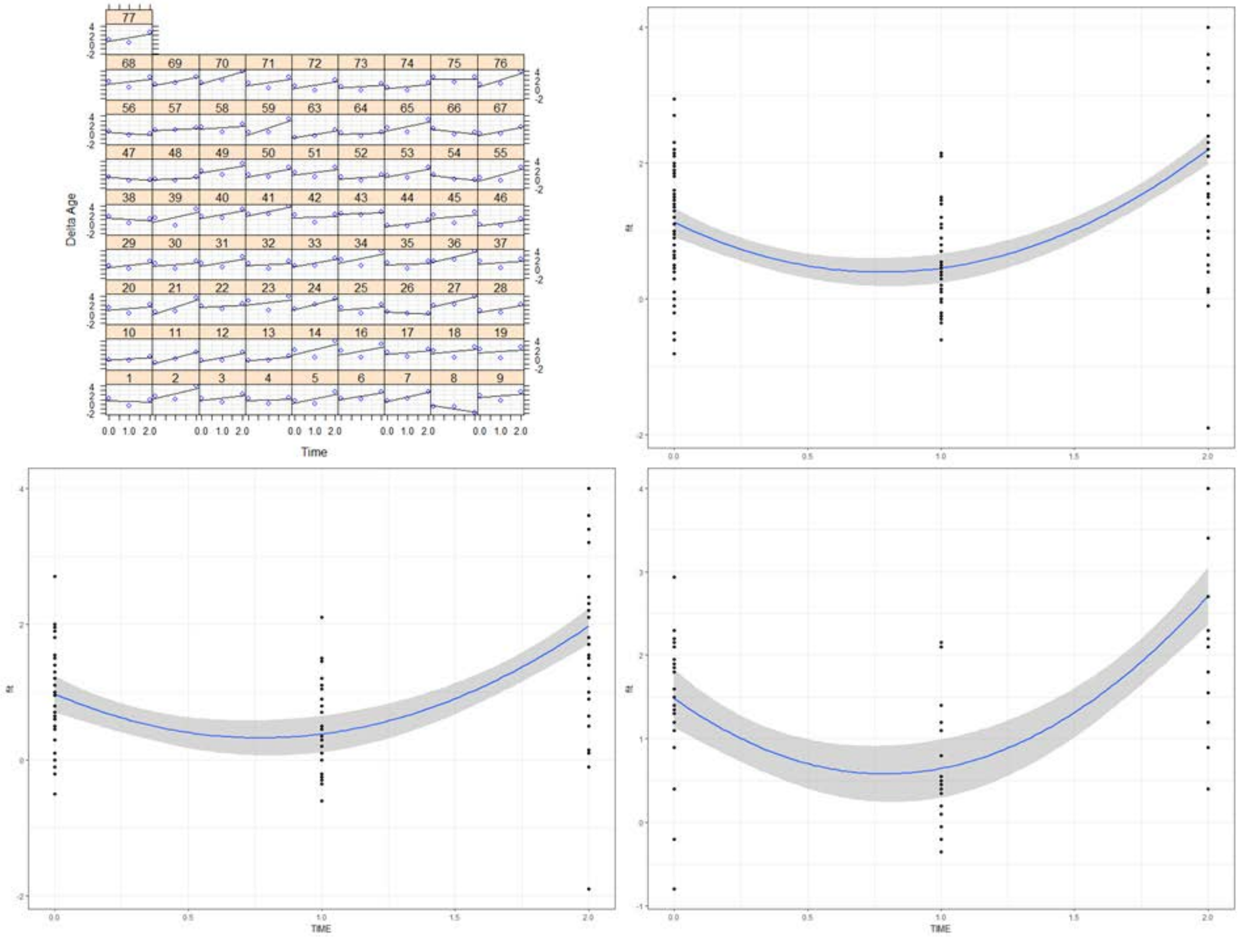

Figure 6. Depictions of longitudinal dental development patterns in our sample. (a) shows individual variation in changes in ΔAge through time. It can be seen that most individuals show an increase over time. (b) shows the pattern of change through time in ΔAge in the aggregate sample. (c) depicts only Normal BMI individuals. (d) depicts only high BMI (Overweight and Obese) individuals. All show a general trend of greater ΔAge at 12 than at 4.

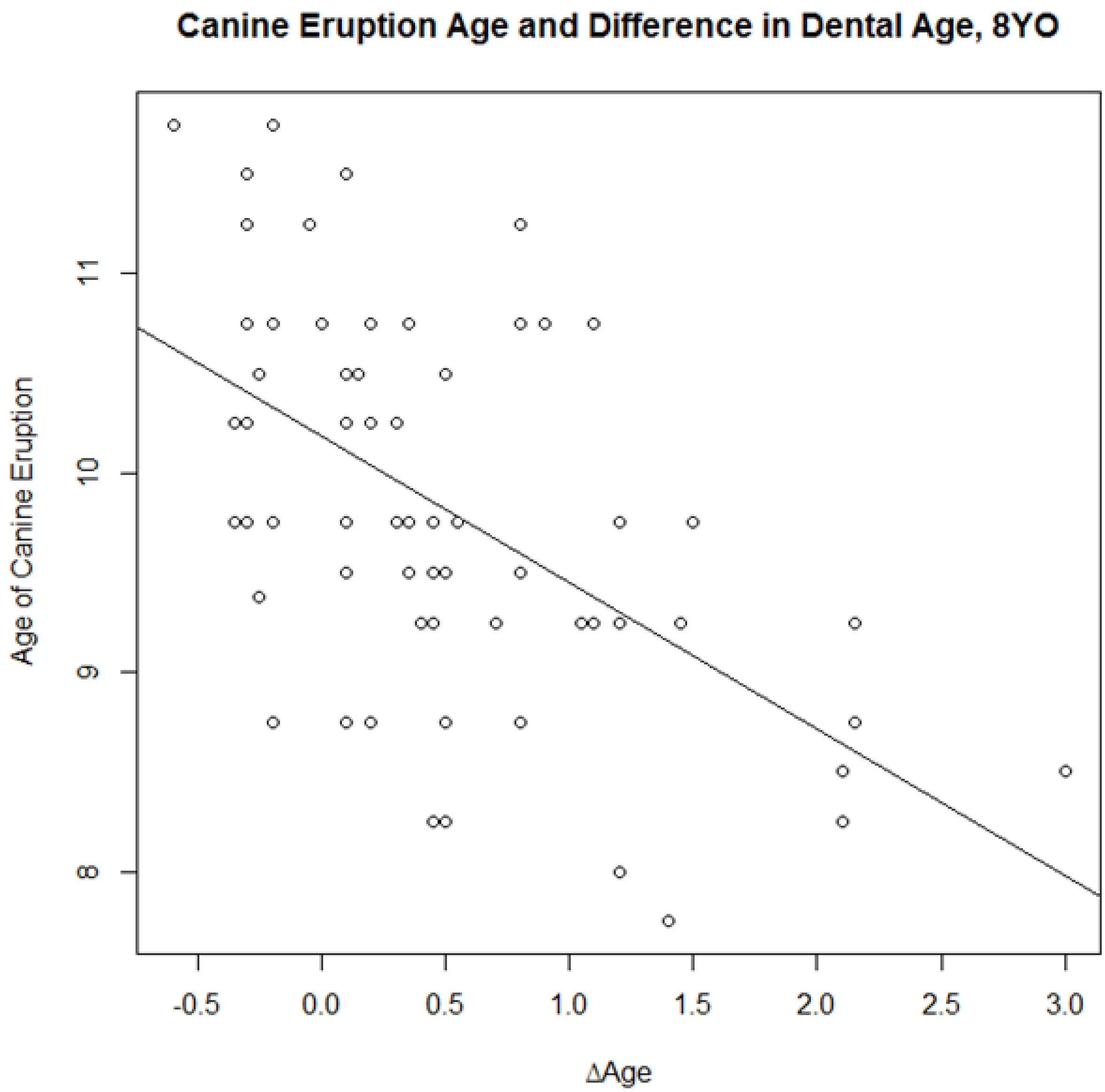

Figure 7. Scatterplot with best fit line depicting the relationship between the age at which an individual erupted their mandibular canines and their estimated ΔAge (in years) at 8 years old. The overall pattern of dental development thus broadly matches the eruption of this specific tooth. It is thus unlikely that earlier eruption in obese children signifies the eruption of underdeveloped teeth.

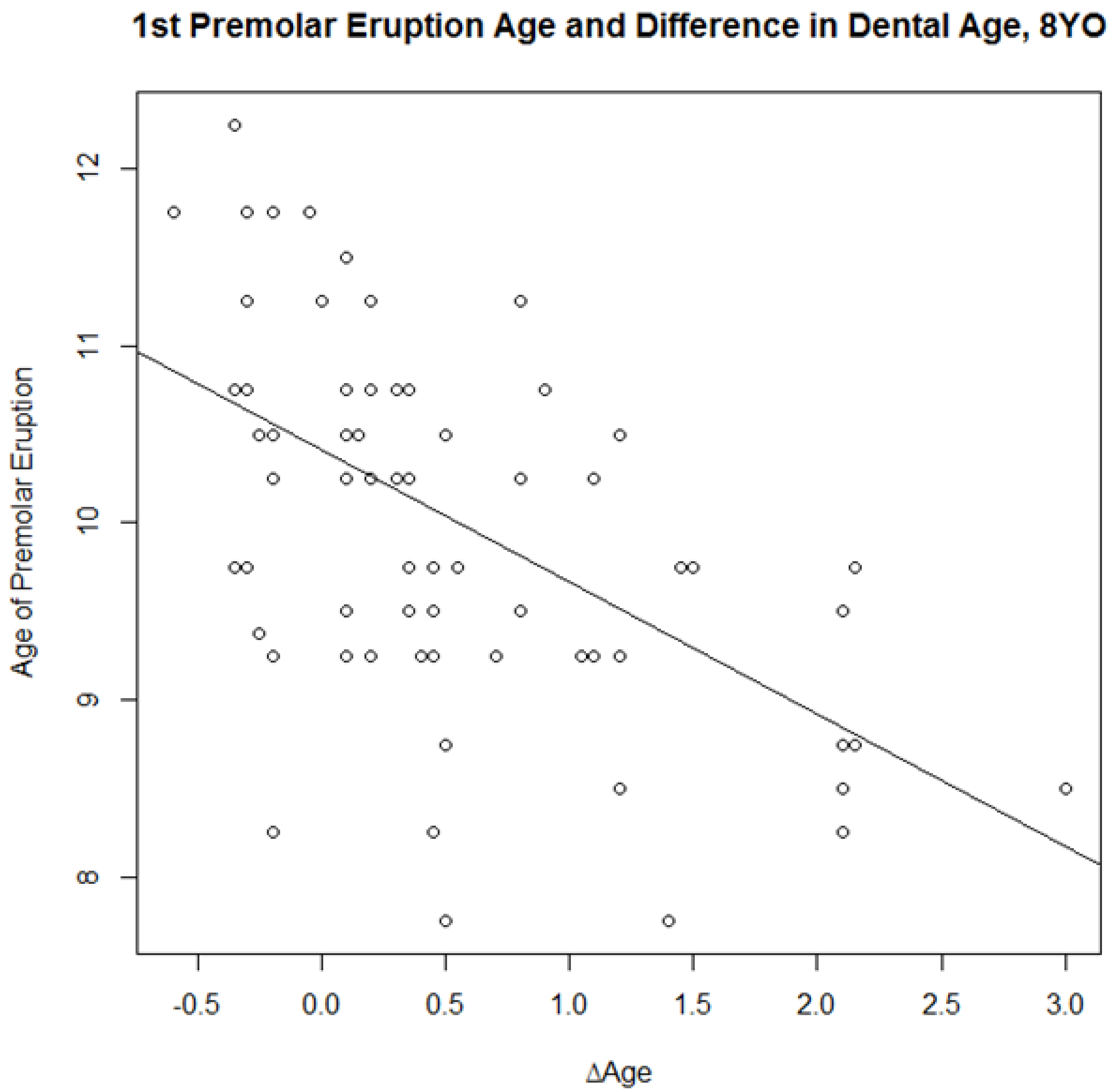

Figure 8. Scatterplot with best fit line depicting the relationship between the age at which an individual erupted their mandibular first premolars and their estimated ΔAge (in years) at 8 years old. The overall pattern of dental development thus broadly matches the eruption of this specific tooth, such that early calcification corresponds to early eruption. It is thus unlikely that earlier eruption in obese children signifies the eruption of underdeveloped teeth. The data represents the aggregate sample of males and females.

Table 1. Body Mass Index (BMI) category cut-offs[31]

BMI Cutoff	Underweight	Normal	Overweight	Obese
Age 4				
Males	<14.0	14.0-17.0	17.01-17.8	>17.8
Females	<13.7	13.7-16.8	16.81-18.0	>18.0
Age 12				
Males	<15.0	15.0-21.0	21.01-24.2	>24.2
Females	<14.8	14.8-20.2	20.21-25.2	>25.2

Table 2. Frequency of weight categories, by age and sex

	Underweight	Normal	Overweight	Obese
Age 4				
Males	N=2	N=22	N=13	N=3
Females	N=1	N=28	N=8	-
Total	*N=3*	*N=50*	*N=21*	*N=3*
Age 12				
Males	-	N=28	N=6	N=6
Females	N=2	N=31	N=4	-
Total	*N=2*	*N=59*	*N=10*	*N=6*

Table 4. The mean difference between Chronological Age and Dental Age (DA-CA= ΔAge), by age and sex

	Mean ΔAge (in years)	Standard deviation
4 years		
F	0.72	0.8
M	1.53	0.57
8 years		
F	0.36	0.879
M	0.62	0.596
12 years		
F	1.89	1.28
M	2.57	1.066

Table 5. The difference in mean ΔAge, by age and weight category[1]

	Mean ΔAge (in years)	Standard deviation

4 years		
Normal	0.99	0.714
Overweight	1.36	0.882
Obese	1.56	1.283
12 years		
Normal	1.99	1.056
Overweight	2.77	1.173
Obese	3.10	0.815

[1]Weight categories were used based on the time point sampled (e.g., 12 years is the data for this age broken down by BMI categories from height/weight data at 12 years)

Table 5. Quadratic mixed effects model with BMI as a predictor for ΔAge

	Value	Standard Error	P-value
Intercept	1.129	0.085	P<0.001
BMI	0.099	0.050	P=0.052