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ORIGINAL ARTICLE

The relationship of obesity to the timing of permanent tooth emergence in Czech children

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ABSTRACT

Background: The aim of this study was to investigate the influence of BMI on the timing of permanent tooth emergence in Czech children.

Objectives: In this cross-sectional study, 1370 Czech children were examined. The age, gender, weight, height, all emerged permanent teeth (except third molars) of each child were all recorded. A tooth is defined as having emerged when at least any part of it has penetrated the gingiva.

Methods: A logistic regression model was used to calculate the median emergence age per tooth for both genders separately and BMI was used as a factor variable to detect statistically significant differences in the times of tooth emergence within pairs of BMI groups. The data were statistically processed using IBM SPSS Statistics 23 (SPSS Inc., Chicago, IL).

Results: Statistically significant differences were found for the following permanent teeth (using the FDI two-digit system): 13, 14, 15, 16, 17, 41, 44, 45, 46, 47, 33, 35, 37, 21, 24, 25, 26, 27 for girls and 12, 13, 14, 15, 16, 41, 43, 44, 45, 22, 25, 32, 34, 35, 36 for boys. These teeth were observed to emerge earlier in obese children. A similar correlation (although not statistically significant) was observed between the time of emergence of the remaining teeth and the BMI of the child.

Conclusion: The data in this research highlight significant differences in emergence times of permanent teeth due to the influence of BMI in Czech children. These findings are important for dental treatment planning.

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Obesity; BMI; tooth emergence; permanent teeth; Czech children

Introduction

Overweight and obesity are the most common nutritional disorders in industrialized countries, and they continue to increase in prevalence [1]. Childhood obesity has become a growing problem in paediatrics particularly due to the changing nutritional habits of children during their later years. Childhood obesity is defined as an accumulation of excess body fat in children. Childhood obesity is related to obesity in adulthood and contributes to a higher prevalence of obesity-related chronic diseases in the adult population such as diabetes, high blood pressure, heart disease, sleep apnoea, and cancer [2].

The most widely used method for evaluating an individual's anthropometric and nutritional status is body mass index (BMI), which is defined as the body mass divided by the square of body height (kg/m^2). Individuals are classified based on BMI as overweight/obese using the universal cut-offs of 25 and 30 kg/m^2 [3]. BMI for children is strongly influenced by age during childhood and adolescence, therefore BMI-for-age rather than BMI has been used to establish reference standards and in the evaluation of overweight/obesity in childhood and adolescence in many countries [4]. The raw measurement of BMI for children is based on accepted BMI reference standards (the percentile growth chart) ideally drawn from charts derived from the population to which they apply [5]. In the Czech Republic, the growth reference data have been regularly updated through nation-wide anthropological surveys of children and adolescents (NAS) [6]. Growth charts for BMI are based on 1991 NAS data, because the rates of those children defined as overweight (over 90th percentile) and those defined as obese (over 97th percentile) have increased in the last quarter century. To construct BMI percentile charts based on recent data would lead to a shift towards higher values for the 90th and 97th percentiles and even for the 50th percentile in some age groups which would be misleading. For this reason, the 1991 percentile has been used [6].

Although the time of emergence of permanent dentition is genetically controlled [7], various external factors such as physical constitution and nutrition [8] can also affect the process of dental development and can accelerate craniofacial growth [9] as well. The other factors influencing the emergence of permanent teeth can be climate [10], socioeconomic status, premature birth, habits during pregnancy [11], circadian rhythm [12], premature loss of deciduous teeth [13], and fluoride intake [14].

The majority of foreign studies focus on the influence of weight on the emergence time of deciduous teeth [15–18].

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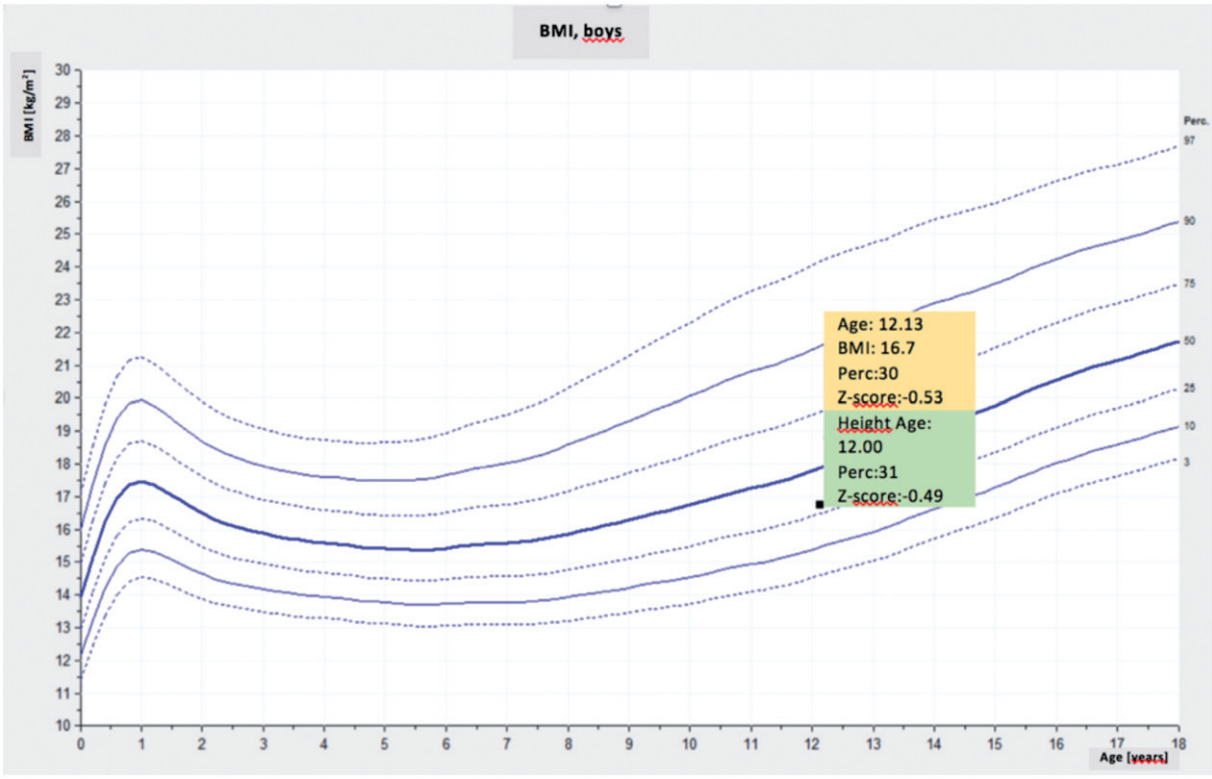

Figure 1. The assessment of BMI for boys. (Expl.: the age, BMI, percentile and Z-score are in the yellow box and in the green box are the same height for age values. Modified according to Softwarový program *Posuzování růstu dětí* (ver. 2.3), aktualizovaná verze z roku 2011, Státní zdravotní ústav, Praha 2005, www.szu.cz.

Fewer studies [19–22] have been undertaken to investigate the association of BMI and the emergence of permanent teeth. Therefore, the aim of our study was to investigate any potential relationship between the premature emergence of permanent teeth and obesity in the Czech paediatric population.

Material and methods

Study population

The study was approved by the Ethics Committee of the General University Hospital in Prague and the data collected in accordance with Act No. 101/2000 Coll. on the Protection of Personal Data. The sample used for this epidemiological survey was 1370 pre- and primary school children (comprising 696 girls (50.8%) and 674 boys (49.,2%)), in the years 2013/2014 and throughout the whole Czech Republic. Selected kindergartens and elementary schools were contacted and detailed information about the study was sent to their principals. Children aged 4–15 years, and whose parents or guardians signed the inform consent forms, were included in the sample group. We proceed it on the understanding that Czech citizens and other minorities of Caucasian [23] origin (e.g. Moravian, Silesian, Slovak, etc.) make up the Czech Republic [24] and only white subjects of European background were included in the study.

Data collection

Procedures for data collection were chosen according to the similar studies conducted in other countries [20,21]. All the subjects were given a 2-min epidemiological dental examination directly in their classrooms by the main author (RS) personally. All emerged teeth, age (within an accuracy to two decimal points), gender were recorded and body weight (with accuracy 0.5 kg) and height (with accuracy 0.5 cm) were measured using an electronic digital scale (Tanita WB 380), according to the method of Martin and Saller [25]. Each emerged permanent tooth in the oral cavity was recorded and identified according to the FDI [26] two-digit system and was classified into two grades: absent, where the tooth is not visible within the oral cavity, and present, where are permanent teeth clinically visible. No data were collected concerning the possible early loss of preceding teeth or a nutrition and socioeconomic class of the examined subjects. BMI were calculated for each child using the *Posuzování růstu dětí* (ver. 2.3) software program of the Czech Institute of Statistics (see Figure 1). Based on gender-specific BMI-for-age growth charts from the 1991 CZ NAS [6], children were classified according to percentile level into two groups (see Table 1): normal weight (25–75 percentile), overweight/obese (90 percentiles and over), due to the fact that in the Czech Republic the 90th percentile is the upper cut-off for identifying overweight children. Children whose BMI-for-age values are over the 97th percentile are identified as obese [27], but for the purposes of this study all subjects over the 90th percentile are considered as one group.

Statistical data analysis

In this study, binary logistic regression models (56 models each for both genders) were applied for the computation of

Table 1. Evaluation of BMI according to Czech BMI-for-age charts. Modified according to Vignerová et al. [6]

Evaluation of BMI	Percentile level	Evaluation according to BMI	This study grouping
High BMI	>97	Obese	Group 2
	90–97	Overweight	
Middle BMI	75–90	Risk of overweight	
	25–75	Normal range (healthy weight)	Group 1
	10–25	Risk of underweight	
Low BMI	3–10	Underweight	
	< 3	Severely underweight	

Table 2. Distribution of the subjects according to gender and BMI (normal weight group, overweight/obese group, the borderline overweight and underweight).

	Normal weight group		Overweigh-obese group		The rest group		Total	
Gender	*N*	Percentage	*N*	Percentage	*N*	Percentage	*N*	Percentage
Girls	366	26.72%	131	9.56%	199	14.53%	696	50.80%
Boys	367	26.79%	140	10.22%	167	12.19%	674	49.20%
Combined genders	733	53.50%	271	19.78%	366	26.72%	1370	100.00%

the median age emergence time per tooth and for the measurement the contribution of BMI grouping – the predictor variable to the prediction of the concrete emergence time of permanent teeth (the dependent variable). The predictor variable was coded as ordinal scale of 1 and 2, where 1 represents the normal weight group and 2 the obese group. The dichotomous dependent variable was coded as 0 for teeth not visible in the oral cavity and 1 for teeth visible in the oral cavity. The statistical significance of the predictor variable influence (BMI group) in the logistic regression equation was evaluated and the odds ratios for BMI variable were calculated for each tooth. The statistical analysis was performed using IBM SPSS Statistics 23 software (SPSS Inc., Chicago, IL). All statistical tests were performed at the 0.05 level of significance. The equation for logistic regression is as follows: $\ln(p/(1-p))=b_0+b_1\text{xAGE}+b_1\text{xBMI}$, where p is the probability of the emergence of the individual tooth, b_0 is the constant, b_1 is the regression coefficient for variable age and b_2 is the regression coefficient for variable BMI. For testing the differences in median time of emergence between boys and girls, binary-independent variables (1 = girl, 0 = boy) were added, so the equation becomes: $\ln(p/(1-p)) = b_0+b_1\text{AGE}+b_2\text{GIRL}$. If there is a difference between normal weight group, and obese group, the parameter for this variable is statistically significant.

Results

Tables 2 and 3 show the distribution of the subjects according to gender and BMI. The age groups of 4 up to 6 and 14 up to 15 contain fewer subjects than the other groups due to an absence of parental permission; however, the percentile distribution of the children is the same in all groups. The prevalence of overweight/obese children is 18.82% in girls and 20.77% in boys based on the 1991 CZ NAS. Tables 4 and 5 set out the results for boys and girls separately for each BMI group. Generally, in almost all of the examined teeth there was a tendency to earlier emergence in the obese group compared with the normal weight group. However, considering the existing tendency, not all of the differences between the times of emergence of corresponding teeth across different BMI groups were statistically significant. The differences of emergence times were statistically significant for teeth 12, 13, 14, 15, 16, 41, 43, 44, 45, 22, 25, 32, 34, 35, 36 for boys and 13, 14, 15, 16, 17, 41, 44, 45, 46, 47, 33, 35, 37, 21, 24, 25, 26, 27 for girls (see Tables 4 and 5). Tables 4 and 5, set out the results of the binary logistic regression models run for each tooth. The odds ratio and the statistical significance of BMI grouping contributing to the prediction of emergence timing are presented in Tables 4 and 5 for each tooth separately. A significant difference was proven between obese and normal weight groups of children with respect to the emergence time of permanent teeth. All odds ratios of the significant models were above the value 1.0 which means that as the BMI of a child becomes higher the likelihood that a tooth will emerge earlier increases by the factor of the odds ratio. Taking the output for tooth 13 in girls as an example, it can be seen that in an increase from normal weight to obesity, the odds that this tooth will emerge earlier increases by a factor of 3.580.

Discussion

The prevalence of obese children in our study is similar to that found in reports from the World Obesity Federation (WOF) [28]. Conversely, the prevalence of obesity is approximately of 5% higher in our 2014 study than in the data published by the National Anthropological Survey in 2001 [6]. Genetic, behavioural and environmental issues are the most likely factors responsible for the rise in the number of obese children in recent years in the Czech Republic. Both an excess intake of high fat foods coupled with a decrease in physical activity substantially increase a child's risk for obesity [29]. The most dramatic changes in growth patterns have been observed among school-aged children, where BMI values have increased at the 50th, 90th and 97th percentiles. This finding is consistent with other observations in the Czech Republic, where 5.6% of boys and 6.6% of girls aged 7–11 years were found to be obese in 2001 [6] compared with only 3% in 1991 [30]. Because of the recent increase in

Table 3. Percentage of overweight/obese and normal weight individuals in 2014 compared to 2001 CZ NAS.

	Girls					Boys				
Age (years)	*N*	Normal weight group		Overweight/obese group		*N*	Normal weight group		Overweight/obese group	
4.00–4.99	15	9	60.00%	2	13.33%	18	5	27.78%	7	38.89%
5.00–5.99	15	10	66.67%	4	26.67%	15	8	53.33%	4	26.67%
6.00–6.99	72	34	47.22%	12	16.67%	73	46	63.01%	13	17.81%
7.00–7.99	108	57	52.78%	18	16.67%	96	51	53.13%	15	15.63%
8.00–8.99	74	32	43.24%	16	21.62%	74	32	43.24%	15	20.27%
9.00–9.99	78	45	57.69%	13	16.67%	76	36	47.37%	20	26.32%
10.00–10.99	88	44	50.00%	21	23.86%	77	41	53.25%	23	29.87%
11.00–11.99	71	40	56.34%	13	18.31%	75	44	58.67%	14	18.67%
12.00–12.99	71	45	63.38%	13	18.31%	72	42	58.33%	13	18.06%
13.00–13.99	82	40	48.78%	12	14.63%	79	51	64.56%	12	15.19%
14.00–14.99	22	10	45.45%	7	31.82%	19	11	57.89%	4	21.05%
Total	696	366	52.59%	131	18.82%	674	367	54.45%	140	20.77%

Table 4. This table sets out the median ages, 5th and 95th percentiles of tooth emergence for girls in groups according to BMI and the statistically significant differences of obese group compared with normal weight group and the outputs of the binary regression test between BMI group and emergence time of all permanent teeth.

			Girls							
			Obese group			Normal weight group				
				Percentile			Percentile			
Tooth			Median	5th	95th	Median	5th	95th	Exp (B)	Sig
Right side	Maxillary	Central incisor	6.87	6.33	7.40	6.92	6.39	7.46	1.368	.636 NS
		Lateral incisor	7.35	6.24	8.46	7.62	6.51	8.73	2.042	.125 NS
		Canine	10.10	9.08	11.12	10.55	9.53	11.57	3.580	**.011 Sig**
		First premolar	9.03	7.78	10.28	9.53	8.28	10.79	3.286	**.012 Sig**
		Second premolar	10.27	9.07	11.47	11.09	9.89	12.29	7.446	**.000 Sig**
		First molar	6.42	5.97	6.88	6.77	6.31	7.22	9.005	**.027 Sig**
		Second molar	12.07	10.97	13.16	12.60	11.50	13.69	4.176	**.008 Sig**
	Mandibular	Central incisor	5.82	4.91	6.74	6.40	5.49	7.31	6.417	**.041 Sig**
		Lateral incisor	6.97	6.27	7.67	7.23	6.53	7.92	2.965	.065 NS
		Canine	8.90	7.82	9.99	9.17	8.09	10.26	2.080	.144 NS
		First premolar	9.47	8.38	10.57	9.87	8.78	10.97	2.924	**.028 Sig**
		Second premolar	10.27	9.10	11.44	10.80	9.63	11.98	3.854	**.004 Sig**
		First molar	5.66	4.93	6.40	6.33	5.60	7.07	14.600	**.027 Sig**
		Second molar	10.96	9.68	12.25	12.12	10.84	13.41	14.277	**.000 Sig**
Left side	Maxillary	Central incisor	6.79	6.17	7.41	6.95	6.33	7.57	2.137	.236 NS
		Lateral incisor	7.29	6.21	8.38	7.57	6.49	8.66	2.162	.101 NS
		Canine	10.05	8.89	11.20	10.64	9.49	11.79	4.542	**.002 Sig**
		First premolar	9.22	8.02	10.43	9.39	8.19	10.60	1.513	.370 NS
		Second premolar	10.32	9.25	11.39	10.99	9.92	12.06	6.349	**.000 Sig**
		First molar	6.48	5.88	7.09	6.60	6.00	7.21	1.810	.443 NS
		Second molar	11.81	10.46	13.17	12.62	11.26	13.98	5.766	**.000 Sig**
	Mandibular	Central incisor	5.44	4.65	6.23	6.31	5.52	7.10	25.926	**.011 Sig**
		Lateral incisor	7.07	6.24	7.91	7.24	6.40	8.08	1.800	.265 NS
		Canine	8.97	7.84	10.10	9.27	8.14	10.40	2.196	.108 NS
		First premolar	9.37	8.55	10.19	9.80	8.98	10.62	4.720	**.008 Sig**
		Second premolar	10.43	9.21	11.66	10.85	9.63	12.07	2.727	**.028 Sig**
		First molar	5.66	4.91	6.41	6.29	5.54	7.04	11.822	**.037 Sig**
		Second molar	11.35	9.91	12.79	11.94	10.50	13.38	3.335	**.007 Sig**

Bold values represent statistically significant results.

childhood obesity, growth charts for Czech children were not updated after the 2001 Nation-wide Anthropological Survey. Rather, reference values derived from the 1991 data have remained in use among researchers and paediatricians in the Czech Republic.

In many countries [4], BMI-for-age has been used to establish reference standards in the evaluation of obesity in childhood and adolescence. Because growth charts are constructed from population data with unique anthropometric characteristics, reference values in each country differ substantially and a variety of cut-off values are used to identify overweight and obese children [5].

An association between the timing of permanent tooth emergence and BMI has been observed previously. A longitudinal study of Mexican children found a significant difference in BMI and tooth eruption patterns, where overweight children had more teeth erupted than children classified as underweight [19]. The cross-sectional study of Hilgers [22] reached similar conclusions and proved that dental age differences significantly grow with increases in BMI. Must cross-sectional research [20] suggests that obese children had 1.44 more teeth erupted then non-obese children and Shaweesh [21] proved that permanent teeth in Jordanian children with

Table 5. This table sets out the median ages, 5th and 95th percentiles of tooth emergence for boys in groups according to BMI and the statistically significant differences of obese group compared with normal weight group and the outputs of the binary regression test between BMI group and emergence time of all permanent teeth.

			Boys								
			Obese group			Normal weight group					
				Percentile			Percentile				
Tooth			Median	5th	95th	Median	5th	95th	Exp (B)	Sig	
Right side	Maxillary	Central incisor	7.11	6.75	7.46	7.07	6.71	7.42	.714	.708	NS
		Lateral incisor	7.63	6.39	8.88	8.15	6.90	9.39	3.392	**.009**	**Sig**
		Canine	10.99	9.78	12.21	11.41	10.19	12.62	2.731	**.032**	**Sig**
		First premolar	9.20	8.19	10.20	9.56	8.55	10.57	2.946	**.035**	**Sig**
		Second premolar	10.62	9.32	11.93	11.06	9.75	12.37	2.670	**.025**	**Sig**
		First molar	6.66	6.10	7.22	6.93	6.37	7.49	4.096	**.057**	**Sig**
		Second molar	12.43	10.87	14.00	12.71	11.14	14.27	1.673	.242	NS
	Mandibular	Central incisor	6.07	5.27	6.87	6.47	5.67	7.27	4.368	**.050**	**Sig**
		Lateral incisor	7.28	6.55	8.01	7.44	6.71	8.17	1.926	.258	NS
		Canine	9.10	8.26	9.93	9.53	8.69	10.36	4.553	**.011**	**Sig**
		First premolar	9.73	8.94	10.52	10.13	9.34	10.92	4.434	**.006**	**Sig**
		Second premolar	10.57	9.26	11.89	11.01	9.70	12.33	2.674	**.023**	**Sig**
		First molar	6.38	5.58	7.17	6.52	5.72	7.32	1.697	.421	NS
		Second molar	12.31	10.57	14.04	12.53	10.79	14.27	1.459	.360	NS
Left side	Maxillary	Central incisor	7.02	6.85	7.18	7.07	6.90	7.24	2.535	.467	NS
		Lateral incisor	7.63	6.41	8.86	8.12	6.90	9.35	3.236	**.012**	**Sig**
		Canine	10.99	9.78	12.20	11.36	10.16	12.57	2.474	.052	NS
		First premolar	9.32	8.44	10.20	9.60	8.72	10.48	2.590	.077	NS
		Second premolar	10.57	9.26	11.89	11.08	9.77	12.40	3.126	**.009**	**Sig**
		First molar	6.80	6.20	7.41	6.92	6.32	7.53	1.792	.391	NS
		Second molar	12.49	11.11	13.87	12.81	11.44	14.19	2.002	.141	NS
	Mandibular	Central incisor	6.04	5.12	6.96	6.34	5.42	7.27	2.625	.169	NS
		Lateral incisor	7.14	6.28	8.00	7.50	6.64	8.36	3.464	**.027**	**Sig**
		Canine	9.15	8.27	10.03	9.44	8.56	10.32	2.625	.081	NS
		First premolar	9.37	8.90	10.56	10.13	9.30	10.97	4.146	**.007**	**Sig**
		Second premolar	10.64	9.11	12.18	11.08	9.54	12.61	2.293	**.039**	**Sig**
		First molar	6.21	5.55	6.87	6.67	6.01	7.33	7.811	**.010**	**Sig**
		Second molar	12.06	10.53	13.60	12.40	10.86	13.94	1.902	.139	NS

Bold values represent statistically significant results.

a higher BMIs emerge earlier compared to children with lower BMIs.

The earlier emergence of permanent teeth in obese children could be explained by adipose tissue regulating hormonal responses and metabolic processes [31]. The expansion of adipose tissue has been observed to lead to hormonal and metabolic changes, such as increased secretion of insulin-like growth factor-1 [32] and mineral metabolism. These factors may both influence accelerated tooth eruption.

Accelerated tooth emergence in obese children results in an increased risk of decay of permanent teeth, because the teeth are in the oral cavity for longer period [33] as compared with children of normal weight. The treatment of tooth decay in younger children is more difficult for dentist due to child's dental anxiety.

The factors that affect dental emergence are significant in monitoring dental development, diagnosing and treating malocclusion at the appropriate time as well as in determining other general diseases connected with earlier or later emergence of teeth. The knowledge of teeth emergence times is also important in forensic anthropology for estimation of an individual's age.

The risk of bias is lower in cross-sectional studies than in longitudinal ones [34]. Respectively, our study protocol was conceived as a cross-sectional anthropological survey focusing on emergence times of permanent teeth in Czech children in dependence on the obesity level of BMI, representing a Central European population sample. It was observed that in children of normal weight all permanent teeth emerge later than in obese ones, but the results were not statistically significant for all teeth.

In conclusion, our study proved the relationship between childhood obesity (measured with body mass index (BMI) and the timing of the emergence of permanent teeth, where the permanent teeth of obese children emerged earlier than those in children of normal weight.

Why this paper is important to paediatric dentists?

1. There is a relationship between childhood obesity and the timing of the emergence of permanent teeth, where the permanent teeth of obese children emerged earlier than those in children of normal weight.
2. Accelerated tooth emergence in obese children results in an increased risk of decay of permanent teeth, because the teeth are in the oral cavity for longer period as compared with children of normal weight. The treatment of tooth decay in younger children is more difficult for dentist due to child's dental anxiety.
3. The factors that affect dental emergence are significant in monitoring dental development, diagnosing and treating malocclusion at the appropriate time as well as in determining other general diseases connected with earlier or later emergence of teeth. The knowledge of teeth emergence times is also important in forensic anthropology for estimation of an individual's age.

Conclusions

Our study has proven the relationship between childhood obesity (measured by BMI) and the timing of the emergence of permanent teeth, where the permanent teeth of obese children in the Czech Republic emerged earlier than those in children of normal weight. Since permanent teeth emerge earlier in obese children, the responsibility for applying early dental care for detecting early caries affecting first molars, may be shifted from primary schools to kindergarten.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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