Evaluation of Serum 25(OH)D Levels in Obese and Normal-Weight Children with Carious and Hypomineralized Teeth

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Aim: *The aim of this study was to assess the association between dental caries, molar incisor hypomineralisation (MIH) and obesity in relationship with different vitamin D levels in children.* ***Study design:*** *This retrospective case-controlled study enrolled 455 children aged 6-18 years, who attended to both pediatric endocrinology and pediatric dentistry clinics at the Aydin Adnan Menderes University Hospital, Turkey. Vitamin D status was measured with serum (25(OH)D) concentrations. Body mass index (BMI) were used to determine adiposity. Caries status was assessed using the decayed-missing-filled teeth (dft) and (DMFT) index for primary and permanent dentitions using WHO standard methodology. MIH were diagnosed according to the EAPD criteria.* ***Results:*** *DMFT did not show any significant difference between obese and normal weight children in both age groups. However, in 6-11 age group, obese children had lower dft and the difference was statistically significant (p<0.001). Median caries index values and MIH prevelance among the obese and normal weight children found similar with deficient, insufficient and sufficient levels of serum 25(OH) D in both age groups.* ***Conclusion:*** *Our analyses provide no evidence to suggest that obese children are at increased risk for dental caries. Serum 25(OH)D concentrations would not seem to have a significant effect on dental caries and MIH in children.*

Keywords: obesity, children, vitamin D, dental caries, MIH

INTRODUCTION

Dental caries is the most common childhood chronic disease, with a prevalence of more than 50% in many countries.[1] Untreated dental caries can lead to serious problems, such as caries-related pulpitis, pain, tooth loss, and other co-morbidities, which can affect nutritional status, growth, development, and quality of life in children.[2]

There is currently an increasing interest in the association between oral health and adiposity status of children as well as adults. Dietary habits, poor oral health behaviors, genetic, and environmental risk factors were assumed to be common contributors to both obesity and dental caries.[3]and 282 of them completed all 3 phases of data collection. Body mass index, waist circumference, waist-to-hip (WHR Systematic reviews have examined the cross-sectional relationship between anthropometric values and dental caries, and a vast of majority of these studies have inconclusive associations.[4–6] A longitudinal study of the association between obesity and dental caries showed that there was no relationship between the two chronic diseases in children and adolescents.[7]

Another important topic addressed by researchers is vitamin D, which has been identified as one of the key nutrients that contributes to the development and maintenance of optimum bone mass, tooth formation, and metabolic reactions.[8] Theodoratou *et al* [8] in their umbrella assessment using a systematic review and meta-analyses showed that dental caries in children is one of the health outcomes associated with vitamin D deficiency. Due to vitamin D's key role

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in hard tissue formation, vitamin D deficiency was also suspected to be one of the causative factors of molar-incisor hypomineralization (MIH)[9], of which the precise etiology is uncertain. MIH is a type of enamel defect affecting, as the name suggests, the first molars and incisors in the permanent dentition.[10] Teeth affected with MIH are at an increased risk of acquiring dental caries and breakdown.[11]

It is well known that even in sunny countries, vitamin D deficiency is observed in different regions and have become a common problem in the world not only for adults, but also for the pediatric population.[12] Measurement of total 25(OH)D levels is the best test to assess body stores of vitamin D; however, there are still different opinions about the threshold value of 25(OH)D for deficiency.[13] Earlier studies from Turkey have noted an extended diversity of vitamin D deficiency in children depending on the population size and threshold used.[13,14]

Since the studies regarding serum 25(OH)D levels in children with dental caries and its connection to body mass index (BMI) are questionable, we designed a retrospective case-controlled study aiming to 1) examine serum 25(OH)D levels in children living in the Aegean region of Turkey, 2) determine the association between obesity and caries status, and 3) investigate the relationship between 25(OH)D, MIH, and caries status.

MATERIALS AND METHOD

Data were collected from patients who attended to both the pediatric endocrinology and pediatric dentistry clinics at the University of Adnan Menderes between December 2016 and June 2017. The medical files of all children were reviewed. Non-syndromic obese children were compared with an age- and sex-matched control group of normal-weight counterparts. The subjects comprised 455 children aged 6–18 years old living in the city of Aydın (Aegean region, Turkey) who participated in blood tests and oral examinations. The Ethics Committee of the University of Adnan Menderes, Faculty of Medicine (Protocol Number: 2016/934) approved the study, which was performed according to the Helsinki Declaration.

Our sample was purposely divided into two main groups and two subgroups depending on BMI and dentition status, respectively. For BMI, the study population was classed into two groups based on whether the children were normal weight or obese using the international BMI cutoff points described by Cole et al[15] Moreover, the BMI percentile specific to age and gender of Neyzi *et al*,[16] a national standard of growth and body composition, was used to classify children as obese (BMI percentile $\geq 95^{th}$), overweight ($\geq 85^{th}$ to $<95^{th}$) and normal weight ($>16^{th}$ to $<85^{th}$).

All children in the study had the criteria of their first permanent molars and incisors being fully erupted. The caries assessment was determined as a tooth- and surface- related DMF index for the primary dentition (dft) and permanent dentition (DMFT) using the WHO standard methodology.[17] The caries status stated in the study was caries prevalence (at least one decayed tooth in any of the dentitions) and caries experience (the total count of decayed and filled teeth in both dentitions). Caries-free children are defined as children with no prior caries experience.

The MIH assessment was determined as follows: demarcated opacities, post-eruptive breakdown (PEB) of the hypomineralized enamel and atypical restorations (ARs) were diagnosed as enamel hypomineralization (EH), according to the EAPD criteria,[11] on all permanent teeth and surfaces. Hypomineralized lesions with a diameter <1 mm were not recorded. EH-associated defects were not scored in the DMF index.

Laboratory results were extracted from the patient records. Children with chronic conditions and those using medication or supplements were excluded from the study. To classify serum 25(OH)D concentrations in our population, the cutoffs reported in the consensus created by Saggese *et al* [18] were used. Vitamin D-deficient concentrations were considered as those ≤12 ng/ml; a level of 12–20 ng/ml was considered to indicate vitamin D insufficiency, and a level of 20 ng/ml or greater was considered sufficient.

Statistical analyses were performed using IBM SPSS Statistics 17.0 (IBM Corporation, Armonk, NY, USA) Mean and standard deviation or median (minimum–maximum) values are given for continuous variables. Categorical variables are expressed as frequencies and related percentage values. They were compared using the chi-square test or Fisher's exact test. Nonparametric tests (Mann–Whitney U, Kruskal–Wallis) were used for data without normal distribution. The DMFT/dft of both groups was divided into caries experience (total number of DMFT and dft separately) and caries prevalence (DMFT>0; dft>0) subgroups. Correlation analysis was carried out to determine the effects of demographic factors on these subgroups of obese and normal-weight children. The effects of oral index scores greater than 0 and all possible factors thought to be effective in predicting the presence of MIH were investigated using a multivariate logistic regression analysis. The adjusted risk ratios were calculated with 95% confidence interval. A p value <.05 was considered to be statistically significant.

RESULTS

A total of 455 children were included into the study. The mean age of the children was 12.3 years (standard deviation: 3.0). The distribution of boys and girls between normal weight and obese children was homogeneous in both 6-11 and 12-18 age group (p=0.442 and p=0.725).

The corresponding median values and standard deviation for the recorded caries index parameters are documented in Table 1 and 2, according to the BMI and 25(OH)D levels. The caries prevalence was found as (DMFT > 0) %67; (dft > 0) %54.1. Caries indexes according to the age groups in the study population found as follows: 6-11 age: DMFT: 1.77±1,99 , dft: 2.71±3.24. 12-18 age: DMFT: 3.54±2.91.

DMFT did not show any significant difference between the obese and normal weight children in both age groups (p>0.05). On the other hand, in 6-11 age group, obese children had lower dft and the difference between obese and normal weight children was statistically significant (p<0.001). Caries prevalence and experience between the obese and normal weight children were similar in 12-18 age group (p>0.05); but the same result was not valid for the 6-11 age group.

Given the whole of the study population, MIH prevalence was %7.3 and ratios of having MIH were statistically similar in both obese and normal weight children with no gender predilection. (p=0.995)

Table-2 shows the multivariate analysis of the association between 25(OH)D levels, caries and MIH prevalence or experience. There were no statistically significant differences in the median caries indexes among the groups with deficient, insufficient and sufficient levels of 25(OH)D in the both 6-11 and 12-18 age groups (p>0.05).

Table-3 shows the median 25-(OH)D levels comparing the caries and MIH prevalence in age groups. As an interesting result, in 6-11 age group, median 25(OH)D level was significantly higher in children had dft than whom with caries free (p=0.013). When controlling the MIH and 25(OH)D levels, there was no statistically significant association between the two variable in both 6-11 and 12-18 age groups (p>0.05).

Among the whole study population, the proportion of children who had sufficient serum 25(OH)D levels in the 6-11 age group was statistically higher than the 12-18 age group; while the ratio of children who had deficient serum 25(OH)D levels were statistically lower when comparing the 12-18 age group (p=0.021). Boys had significantly higher 25(OH)D levels than in girls (p <0.001). Furthermore, there was a statistically significant and inverse correlation between age and serum 25(OH)D levels (r=-0.154 and p<0.001).

Table-1: Caries prevalence and experience and MIH status of the children according to body mass index in age groups.

	6-11 age				12-18 age			
Demographics								
Girls	128 (%57.7)				132 (%56.7)			
Boys	94 (%42.3)				101 (%43.3)			
	Normal weight(n=74)	**Obese (n=148)**	**p-value**	**Total (n=222)**	**Normal weight(n=71)**	**Obese (n=162)**	**p-value**	**Total (n=233)**
DMFT	1.85±1.87	1.72±2.05	0.398†	1.77±1.99	3.51±3.12	3.56±2.83	0.793†	3.54±2.91
DMFT > 0	46 (%62.2)	77 (%52.0)	0.152‡	123 (%55.4)	52 (%73.2)	130 (%80.2)	0.308¶	182 (%78.1)
dft	4.22±3.79	1.95±2.64	**<0.001†**	2.71±3.24	-	-	-	-
dft > 0	51 (%68.9)	69 (%46.6)	**0.002‡**	120(%54.1)	-	-	-	-
MIH								
Teeth (n)	0.34±1.14	0.25±0,99	0.595†	0.28±1.04	0.13±0.61	0.17±0.67	0.392†	0.16±0.65
Children (n)	7 (%9,5)	11 (%7.4)	0.794¶	18 (%8.1)	3 (%4.2)	12 (%7.4)	0.563$	15 (%6.4)

† Mann Whitney U test, ‡ Pearson's chi square test, ¶ Continuity-corrected chi-square test, $ Fisher's exact test.

Table-2: Caries prevalence and experience and MIH status of the children according to 25-(OH) D levels in age groups.

	6-11 age				12-18 age			
Serum 25-(OH)D	**Deficiency (≤12 ng/ml) (n=41)**	**Insufficiency (12-20 ng/ml) (n=118)**	**Sufficiency (20 ng/ml) (n=63)**	**p-value**	**Deficiency (≤12 ng/ml) (n=68)**	**Insufficiency (12-20 ng/ ml) (n=114)**	**Sufficiency (20 ng/ml) (n=51)**	**p-value**
DMFT	2.24±2.46	1.74±1.92	1.51±1.74	0.383†	3.99±2.94	3.36±2.92	3.37±2.86	0.258†
DMFT >0	23 (%56.1)	68 (%57.6)	32 (%50.8)	0.675‡	56 (%82.4)	86 (%75.4)	40 (%78.4)	0.550‡
dft	2.12±3.26	2.87±3.41	2.78±2.90	0.213†	-	-	-	-
dft > 0	16 (%39.0)	65 (%55.1)	39 (%61.9)	0.069‡	-	-	-	-
MIH								
Teeth (n)	0.07±0.47	0.25±1.03	0.46±1.28	0.161†	0.01±0.12	0.23±0.82	0.20±0.63	0.123†
Children (n)	1 (%2.4)	9 (%7.6)	8 (%12.7)	0.166‡	1 (%1.5)	9 (%7.9)	5 (%9.8)	0.075¶

† Kruskal Wallis test, ‡ Pearson's chi square test, ¶ Likelihood-Ratio test.

Table-3: Median 25-(OH)D levels comparing the caries and MIH prevalence in age groups.

	6-11 age			12-18 age		
	n	**Median 25(OH)D (ng/ml)**	**p-value**	**n**	**Median 25(OH)D (ng/ml)**	**p-value †**
DMFT			0.672			0.562
DMFT = 0	99	17.62±6.82		51	17.24±10.40	
DMFT>0	123	17.39±7.09		182	15.53±6.87	
dft			**0.013**			-
dft=0	102	16.52±6.76		-	-	
dft>	120	18.31±7.05		-	-	
MIH			0.061			0.069
-	204	17.26±6.95		218	15.73±7.81	
+	18	20.11±6.66		15	18.50±7.22	

† Mann Whitney U test.

DISCUSSION

The purpose of our study was to examine a possible association between dental caries and obesity and investigate the potential role of vitamin D on this association in children 6-18 years of age using data collected from the records. Our analyses provide no evidence to suggest that obese children are at increased risk for dental caries. Indeed, while not entirely consistent, the data suggest that adiposity might be associated with a slightly reduced risk for caries in 6-11 age in primary dentition. No significant association was found in caries status and BMI in permanent dentition both in 6-11 and 12-18 age groups.

The previous studies that examined the relationship between BMI and caries have been sparse and inconclusive. Studies linking obesity and caries in children have including positive associations[19]290 elementary school children (648 boys, 642 girls, no associations[20], and inverse associations.[21,22] Chen et al[23], in their recent systematic review and meta-analysis, declared that no consistent association between dental caries and any weight group in children both primary and permanent dentition.

Similarly, to the above, there have been contradictory findings from studies in Turkey. The cross-sectional study by Köksal *et al* [24] showed that overweight children had lower prevalence (66.1%) of dental caries than the underweight ones (89.7%) whose age ranged from 5 to 9 years. Bulut *et al* [25], in their case-control study, suggested that obesity seems to be not a potential risk factor for dental caries in primary dentition, but there was a statistically significant association in permanent dentition.

In our study, 6-11 age group, caries prevalence and experience was lower in obese children than in normal weight children. Similar observation was made in several studies on primary dentition.[26–29] A recent review[6], which evaluated the correlation between obesity and dental caries in children, found that dental caries were more common in obese children than in normal weight children in permanent dentition; but the same study did not find any correlation in primary dentition. As an interesting result, we found not only a lack of association but a reverse correlation between dental caries and body weight for the primary dentition; confirming the results of previous studies.[26,29,30] We might explain this finding possibly that carious primary teeth may have exfoliated and caries in the permanent dentition may not have had sufficient time to develop. Accelerated linear growth and sexual maturation is associated with adiposity and primary teeth exfoliate earlier in overweight and obese children.[31] This could lead to false positive assessment of caries status.

Our findings that obesity is not linked to dental caries is in contrast with numerous clinical studies. According to many researchers, obese children have significantly more caries in their primary and permanent teeth than lean children. However, they stated that obesity is not the only etiological factor for the caries formation. These disparity may be caused by variations in study design, area and the age of the participants.[32] Furthermore, caries indexes and BMI cut-off values differed across the studies. Several authors also hypothesized that BMI may not be the most suitable tool for assessing a child's weight status when investigating the association between obesity and caries. Possibly we could say that the evidence is inadequate to explain the link between obesity and dental caries solely based on cariogenic food consumption.

To the best of our knowledge, there is no study in the literature that investigated the link between dental caries and obesity and the possible effects of vitamin D on these two chronic conditions. Although there are studies asserting a decrease in serum 25(OH) D levels in the presence of obesity; in our study, serum 25(OH)D levels did not show any difference between the obese and normal weight groups. In order to give an idea about this topic, children also need to be evaluated in more detailed which included serum glucose and lipid metabolism biomarkers.

Many studies in the literature have claimed that vitamin D can prevent inception and development of dental caries. Mellanby *et al* [33] showed an association between vitamin D supplementation and reduced caries risk in their results. Vitamin D in the first few years of life may be prophylactic for dental caries, as also studied by Hujoel *et al* [34] On the other hand, Gyll *et al* [35], in their follow-up study, showed that vitamin D status at 6 years of age was unrelated to enamel defects; but associated with saliva LL37, an innate immunity peptide attacking cariogenic bacteria, for which expression has been linked to vitamin D status. In studies using national representative data from researchers, Schroth *et al* [36] suggested that there is an association between caries and lower serum 25(OH)D levels in Canadian children. Inversely, Herzog *et al* [37] concluded that they did not find a significant association between serum 25(OH)D levels and caries experience in US children.

Our findings showed that the prevalence of MIH was similar in the population; deficient, insufficient and sufficient 25(OH)D levels at any age group. MIH prevalence was %7.3 and the ratios of children with MIH were statistically similar in both obese and normal weight children. (p=0.995)

Kühnisch and colleagues[9]the precise etiology of molar-incisor hypomineralization (MIH, investigated the relationship between MIH and 25(OH)D for the first time in the literature. MIH was diagnosed in %13.6 of their study population and mean concentration of 25(OH)D was 75.8 nmol/l (standard deviation 22.0 nmol/l). Furthermore, they found that higher 25(OH)D values was significantly associated with a lower OR of having hypomineralized teeth, and a reduced incidence of caries. Ghanim et al[38]there has been increasing interest worldwide in investigation of the prevalence of demarcated opacities in tooth enamel substance, known as molar–incisor hypomineralisation (MIH, examined 810 children and (%20.2) presented MIH lesions at least one index teeth and they found interestingly that obesity was negatively correlated to children having MIH.

Median serum 25(OH)D level was measured as 16.67 (ng/ml) in our study. Unfortunately seen from this result, children with vitamin D deficiency (24.0%) and insufficiency (51.0%) were in the majority. Although our data being represented the different seasons to avoid the radiation effects in vitamin D, the high frequency of lower vitamin D levels in the population conferred a very narrow range of serum 25(OH)D concentrations, so making comparisons could be limited. Nevertheless, these results are in concordance with the studies performed in our country. Gultekin et al.[39] determined a vitamin D deficiency of 10.45% in children aged 6–17 years age. Another study in Turkey found subclinical vitamin D insufficiency in 40% of healthy female adolescents.[40] These data emphasize the problematic situation even in the sunny climate of Turkey.

Our findings must be evaluated within the confirmed limitations. First, it was a retrospective study; therefore, there is no inference in terms of causes and effects. Long-term follow-up studies would give us more detailed information about these complex interactions. Second, we had no data about socioeconomic status of children; but we know that the university have a comprehensive hospital in the Aydın city where patients from many different social backgrounds apply. Third, dietary data was not available and we could not obtain data about oral hygiene habits due to the most of the children in the study did not know if they were using fluoridated paste. Moreover, those patients hadn't informed about correct tooth-brushing techniques or proper eating habits before the study. So, it could be difficult to speculate between the groups in terms of info and awareness background. For these reasons, although the sample size does not represent the whole population, it could be demonstrated that the number of patients are superior compared to other studies and represents a population with as homogeneous distribution as possible. Another issue to consider, caries indexes and obesity indices differed across the studies. Different methods complicate standardization and makes difficult to compare with studies in the literature.

Our research would allow considerations for the association of serum 25(OH)D concentrations during hard tissue mineralization and the clinical status after tooth eruption. Additionally, pubertal status of children has not been questioned in our research. Sexual maturation is associated with adiposity and growing age may alter vitamin D; biomarkers (eg: calcium, phosphate and PTH) having direct effects on final 25(OH)D concentrations. So, these important headings could lead another study subject.

CONCLUSIONS

Our study provides no evidence to suggest that obese children are at increased risk for dental caries. Furthermore, serum 25(OH)D concentrations would not seem to have a significant effect on dental caries and MIH lesions. Given the lack of consensus regarding the association between vitamin D and dental caries, highlighting the issue by further studies is important to guide future prevention and treatment efforts. It is worthwhile to emphasize that pediatric dentists are reminded they still have an important role in influencing eating habits and food choices.

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