Tooth brushing and cardiometabolic risk factors in adolescents: Is there an association? The CASPIAN-III study

Roya Kelishadi, Parisa Mirmoghtadaee, Mostafa Qorbani[1,2], Mohammad Esmaeil Motlagh[3,4], Ramin Heshmat[5], Mahnaz Taslimi[6], Minoosadat Mahmoudarabi[4], Gelayol Ardalan[4], Bagher Larijani[7]

Department of Pediatrics, Child Growth and Development Research Center, Isfahan University of Medical Sciences, Isfahan, Iran, [1]Department of Public Health, Alborz University of Medical Sciences, Karaj, Iran, [2]Department of Epidemiology and Biostatistics, Tehran University of Medical Sciences, Tehran, Iran, [3]Department of Pediatrics, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, [4]Department of Youths, Adolescents and School Health, Bureau of Population, Family and School Health, Ministry of Health and Medical Education, Tehran, Iran, [5]Department of Epidemiology, Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Endocrinology and Metabolism Research Institute, Tehran University of Medical Sciences, Tehran, Iran, [6]Department of School Health, Bureau of Health and Fitness, Ministry of Education and Training, Tehran, Iran, [7]Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Endocrinology and Metabolism Research Institute, Tehran University of Medical Sciences, Tehran, Iran

Correspondence to:
Dr. Parisa Mirmoghtadaee,
Specialist in Community and Preventive Medicine, Child Growth and Development Research Center, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: mirmoghtadaee@gmail.com

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ABSTRACT

Background: A growing body of evidence supports an association between oral health and cardiovascular diseases and diabetes in adults. This study aimed to investigate the relationship between tooth brushing frequency and cardiometabolic risk factors in adolescents.

Methods: This nationwide population-based study was conducted among 5258 Iranian students, aged 10-18 years, living in urban and rural areas of 27 provinces in Iran. The association of tooth brushing frequency was assessed with anthropometric indexes and cardiometabolic risk factors after adjustment for potential confounders.

Results: Higher frequency of tooth brushing was associated with lower mean levels of low-density lipoprotein cholesterol (LDL-C) in both genders ($P < 0.0001$) and lower frequency of elevated LDL-C in girls ($P = 0.03$). The frequency of elevated blood pressure decreased with higher tooth brushing frequency in boys ($P = 0.03$). After adjustment for many potential cofounders such as age, gender, anthropometric indexes, screen time, socioeconomic status, and family history of non-communicable diseases, participants who washed their teeth at least once a day had lower risk of high LDL-C and low high-density lipoprotein cholesterol (HDL-C) levels in comparison to those who reported lower frequency of tooth brushing; some different associations were observed among girls and boys.

Conclusions: Our findings suggest an independent and protective role of teeth brushing frequency for some cardiometabolic risk factors in adolescents. Increasing both the general health awareness and improving oral health should be considered in primordial and primary prevention of non-communicable diseases.

Keywords: Blood pressure, cardiometabolic risk factors, lipid profile, obesity, prevention, tooth brushing

Original Article

INTRODUCTION

Nowadays it is well documented that lifestyle behaviors and the tracking of risk factors from early life are associated with the development of chronic non-communicable diseases.[1] Clustering of cardiometabolic risk factors and metabolic syndrome (MetS)

are of the main predisposing factors of chronic diseases. This is of special concern for low- and middle-income countries, which are facing an epidemiological transition and an epidemic of chronic diseases.[2]

Various genetic and environmental determinants have been proposed for the development of chronic diseases and their risk factors.[3] Recently, the possible associations of oral health with cardiometabolic risk factors have been investigated in some studies.[4-7] Inflammation in both conditions may be responsible for this relationship. Poor oral hygiene, which is the major cause of oral disease, may induce systemic inflammatory response.[7,8] Likewise, the role of inflammatory markers in diabetes, hypertension, and cardiovascular disease is well documented.[7,9] Most of these studies have been conducted in adult populations; in our previous study among adolescents, we documented an association between dental caries and cardiometabolic risk factors.[10]

Tooth brushing with regular and effective removal of bacterial plaque from the teeth prevents many periodontal diseases and their associated diseases. A study in adult population found that lower frequency of tooth brushing was associated with a higher prevalence of cardiometabolic risk factors in both genders.[11] Likewise, another study in adults demonstrated that participants who brushed their teeth less often had increased risk of cardiovascular diseases.[12,13]

Limited experience exists about the relationship of tooth brushing with cardiometabolic risk factors in the pediatric age group. Nationwide studies revealed high prevalence of MetS in Iranian adults and children and adolescents.[14,15]

In this study, we investigated the association between the frequency of teeth brushing and cardiometabolic risk factors among 10-18-year-old adolescents in a nationwide study in Iran.

METHODS

We used the data of 5258 students aged 10-18 years who participated in the third national survey of a school-based surveillance program entitled Childhood and Adolescence Surveillance and PreventIon of Adult Non-communicable disease (CASPIAN-III) Study. The details of this study have been described in earlier reports,[16,17] and here we present the methods in brief.

The study was approved by the ethics committees and other relevant national regulatory organizations. Written informed consent and oral assent were obtained from parents and students, respectively. Questions related to family history of chronic diseases and socio-demographic status were included in the parents' questionnaires. In addition, detailed operation manual was developed and distributed among the study team. One team of external evaluators and supervisors nominated by two collaborating ministries checked the performance of the personnel, and monitored and calibrated the equipment according to standard protocols. The Data and Safety Monitoring Board of the project has taken into account different levels of quality control for the study to be successful.

Study population

This study was conducted in urban and rural areas of 27 provincial counties in Iran. Schools were stratified based on information bank of Ministry of Education and then randomly selected. The students were selected by multistage random cluster sampling. Those students with chronic disease and those taking medications were not included in the survey.

Physical examination

A team of trained physicians, nurses, and healthcare providers conducted the physical examination under standard protocols and by using calibrated instruments. Weight, height, and waist circumference (WC) were measured. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). Systolic and diastolic blood pressure (SBP and DBP) were considered as the first and fifth Korotkoff sounds.[18]

Biochemical tests

After instructing the students to fast for 12 h before blood sampling**,** blood samples were taken from the antecubital vein between 8:00 and 9:30 a.m. The samples of blood were centrifuged for 10 min at 3000 rpm within 30 min of venipuncture. Fasting blood glucose (FBG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were measured. Biochemical analysis was performed in the Central Provincial Laboratory following the standards of the National Reference Laboratory,

which is a collaborating center of the World Health Organization (WHO) in Tehran.

Definition of cardiometabolic risk factors

We used the WHO growth curves to define BMI categories, i.e. underweight as age- and gender-specific BMI-for-age value of <–2 z-score, overweight as age- and gender-specific BMI-for-age value of >+1 z-score, and obesity as age- and gender-specific BMI value of >+2 z-score.[19] Abdominal obesity was defined as waist-to-height ratio of more than 0.5.[20]

Abnormal serum lipids were defined as TC, LDL-C, and/or TG higher than the level corresponding to the age- and gender-specific 95th percentile, and also HDL-C lower than age- and gender-specific 5th percentile.[21] High FBG was determined with levels equal or more than 100 mg/dl.[22] The average of SBP or DBP above the 90th percentile for that age and gender after adjusting for weight and height was considered as elevated BP.[18]

MetS was defined based on criteria analogous to the definition of International Diabetes Federation for MetS in the pediatric age group.[22]

Statistical analysis

We categorized general characteristics of the participants under the categories of self-reported frequency of tooth brushing including rarely/never, once a day, and more than once a day. We used Chi-square test for calculating differences of qualitative characteristics as a percentage according to the frequency of tooth brushing. One-way analysis of variance (ANOVA) with *post-hoc* test was performed to evaluate significant differences in general characteristics (e.g., age, BMI, WC, weight, and height) as mean ± standard deviation (SD) according to the categories of tooth brushing frequency. The mean serum lipid profile FBG and BP are reported by using ANOVA with 95% confidence interval (95% CI) according to different categories of tooth brushing frequencies. We used multivariable logistic regression and odds ratios (ORs) with 95% CI to determine the association between cardiometabolic risk factors and tooth brushing frequency. In multivariable logistic regression, we used different models adjusted for several potential confounders. Statistical analysis was performed by using the SPSS for Windows software (version 16.0, SPSS, Chicago, IL, USA), and $P < 0.05$ was considered as statistically significant.

RESULTS

The current study comprised 2593 girls and 2665 boys, with a mean age of 14.7 ± 2.4 years. Table 1 presents the mean (SD) of age, anthropometric measurements, socioeconomic status, and family history of chronic diseases, according to the categories of tooth brushing frequency in girls and boys. The corresponding figures for mean of cardiometabolic risk factors and the frequency of these risk factors are presented in Table 2. Increase in the frequency of tooth brushing was associated with lower mean levels of low LDL-C in both genders ($P < 0.0001$); the corresponding figure for elevated LDL-C level was significant only in girls ($P = 0.03$). The frequency of elevated BP decreased with increasing frequency of tooth brushing in boys ($P = 0.03$).

Multivariate adjusted ORs for cardiometabolic risk factors by categories of tooth brushing frequency after adjustment for age, gender, BMI, duration of television watching and using computer, socioeconomic status, and family history of chronic diseases are presented in Table 3. After adjustment for many potential cofounders such as age, gender, anthropometric indexes, screen time, socioeconomic status and family history of non-communicable diseases, participants who washed their teeth at least once a day had lower risk of high LDL-C and low HDL-C levels in comparison to those who reported lower frequency of tooth brushing; some different associations were observed among girls and boys.

DISCUSSION

To the best of our knowledge, this study is the first of its kind in evaluating the association of the frequency of tooth brushing with cardiometabolic risk factors in a large nationwide population in the pediatric age group. We found significant relationships between lower frequency of tooth brushing and higher mean and frequency of some cardiometabolic risk factors. It is noteworthy to mention that the statistical analysis after adjustment for various potential cofounders confirmed the independent association of lower

Table 1: Characteristic of participants according to tooth brushing frequency categories: The CASPIAN-III study

Charatericics	Tooth brushing frequency (per day)			
	Rarely or never	Once per day	More than once per day	*P value**
Boys				
Age (years)	14.52±2.42	15.01±2.42	16.47±2.46	<0.001
Waist circumference (cm)	67.66±22.3	67.77±25.56	67.12±12.30	0.87
Body mass index (kg/m^2)	19.58±4.10	19.20±4012	19.33±4.22	0.10
Watching TV (%)				
<2 h	52.80	49.30	50.50	0.20
>2 h	47.2	50.70	49.50	
Using computer (%)				
<2 h	91.50	94.10	91.60	0.20
>2 h	8.70	5.90	8.40	
Socioeconomic status (%)				
Private home	78.7	79.20	82.30	0.14
Rented home	21.2	20.8	17.70	
Family history				
Diabetes (%)	45.60	35.30	32.50	<0.001
Obesity (%)	49.0	35.90	43.0	<0.001
Hyperlipidemia (%)	49.60	38.20	36.60	<0.001
Hypertension (%)	57.10	47.60	45.50	<0.001
Osteoporosis (%)	23.60	13.90	16.20	<0.001
Girls				
Age (years)	14.47±2.30	15±2.43	14.89±2.35	0.001
Waist circumference (cm)	69.20±11.38	71.20±23.94	69.32±2.22	0.40
Body mass index (kg/m^2)	19.09±4.08	19.59±4.20	19.07±4.22	0.10
Watching TV (%)				
<2 h	50.50	47.70	46.40	0.17
>2 h	49.50	52.30	53.60	
Using computer (%)				
<2 h	86.10	87.60	87.60	0.5
>2 h	13.90	12.30	12.40	
Socioeconomic status (%)				
Private home	79.10	80.60	84.40	0.4
Rented home	20.90	19.40	15.60	
Family history				
Diabetes (%)	40.30	31.40	31.40	<0.001
Obesity (%)	41.30	33.80	36.60	0.02
Hyperlipidemia (%)	46.40	37.80	37.30	<0.001
Hypertension (%)	52.10	45.70	45.20	0.01
Osteoporosis (%)	21.50	13.30	13.80	<0.001

**P* values are calculated from analysis of variance (ANOVA) for continuous variables and Chi square for categorical variables

frequency of teeth brushing with higher TG and LDL-C levels in adolescents.

Some of our findings in the pediatric age group are consistent with previous studies conducted among adult population. In a study among a large Japanese population, daily teeth brushing was associated with lower prevalence of cardiometabolic risk factors both in men and in women, and with lower prevalence of diabetes mellitus, hypertension, hypertriglyceridemia, and/or low HDL-C.[11]

In a 3-year cohort study among 36-54-year-old

Table 2: Mean levels of cardiometabolic risk factors in participants according to tooth brushing frequency categories: The CASPIAN-III study

Cardiometabolic risk factors	Tooth brushing frequency (per day)			
	Rarely or never	Once per day	More than once per day	*P value**
Boys				
HDL (mg/dl)	45.18±14.82	48.22±13.84	46.40±13.11	<0.001
LDL (mg/dl)	87.36±27.63	85.18±27.29	84.90±25.7	<0.001
TG (mg/dl)	94.18±42.48	94.84±40.52	93.21±36.81	0.8
TC (mg/dl)	150.16±31.26	153.67±32.70	149.26±30.06	0.02
FBG (mg/dl)	86.73±15.02	87.73±12.02	86.25±18.24	0.19
SBP (mmHg)	101.49±14.22	101.80±13.40	101.13±12.34	0.4
DBP (mmHg)	64.70±10.70	65.02±10.45	64.86±9.76	0.7
Girls				
HDL (mg/dl)	45.44±14.84	45.89±14.20	46.74±13.77	0.2
LDL (mg/dl)	86.16±29.11	79.57±25.51	79.54±26.02	<0.001
TG (mg/dl)	91.34±43.65	92.20±45.55	91.77±44.13	0.9
TC (mg/dl)	147.03±32.21	147.03±32.21	145.13±30.53	0.2
FBG (mg/dl)	87.27±12.91	88.66±12.53	88.9±12.75	0.02
SBP (mmHg)	104.42±13.63	105.96±14.54	104.55±13.47	0.04
DBP (mmHg)	67.12±10.63	67.19±11.37	86.51±11.44	0.3

HDL=High-density lipoprotein, LDL=Low-density lipoprotein, TG=Triglycerides, TC=Total cholesterol, FBG=Fasting blood glucose, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, **P* values are resulted from analysis of variance (ANOVA)

individuals, lower rate of MetS was observed among the participants who brushed their teeth for at least two times a day in comparison to those who did it once a day or less.[12]

Several studies in the adult population proposed a relationship between poor oral health and non-communicable diseases and their risk factors. A recent systematic review and meta-analysis presented clear evidence for an association between periodontitis and MetS.[23]

A 4-year cohort study evaluated the causal relationship of periodontal pockets and development of MetS among adults. It revealed that the presence of periodontal pockets was associated with a positive conversion of one or more metabolic components, notably for hypertension and dyslipidemia.[24]

In a study among patients hospitalized because of stroke, periodontitis was documented as an independent risk factor only in younger patients and men. Periodontitis was associated with cerebral ischemia caused by large artery atherosclerosis, as well as with cryptogenic stroke and with cardioembolism.[25]

Different mechanisms, including inflammation, prothrombotic state, recurrent bacteremia, platelet activation, and elevated clotting factors, are proposed as the underlying causes for association of chronic oral infections with cardiovascular diseases.[25,26] We did not find significant association between the frequency of tooth brushing and MetS in adolescents; this may be because of the very young age of our population. It is suggested that such an association may develop over time.

In adults, periodontal diseases are among the most prevalent oral diseases, whereas in children and adolescents, dental caries is the most prevalent oral disorder.[27] Nonetheless, some studies among adults[28,29] and our previous study among adolescents[10] demonstrated association of dental caries with cardiometabolic risk factors.

Dental caries is a multi-factorial infectious disease.[30] The inflammation induced by dental caries might increase the frequency of cardiometabolic risk factors. Many studies reported the association of dental caries with obesity.[31-36] A systematic review and meta-analysis confirmed

Table 3: Odds ratio (95% CI) for cardiovascular risk factors by categories of tooth brushing frequency: The CASPIAN-III study

Cardiometabolic risk factors	Tooth brushing frequency (per day)	
	Once per day/ rarely or never	More than once a day/rarely or never
Overweight and obesity		
Model I	0.96 (0.79-1.08)	0.72 (0.60-0.83) [a]
Model II	0.95 (0.81-1.21)	0.78 (0.64-0.65)
Model III	0.93 (0.77-1.12)	0.76 (0.65-0.95) [a]
Generalized obesity		
Model I	0.98 (0.79-1.21)	0.83 (0.65-1.06)
Model II	1.01 (0.81-1.25)	0.89 (0.70-1.14)
Model III	1.02 (0.80-1.29)	0.86 (0.65-1.14)
Abdominal obesity		
Model I	1.01 (0.86-1.19)	0.85 (0.71-1.03)
Model II	1.00 (0.8-1.18)	0.81 (0.67-0.99) [a]
Model III	1.03 (0.85-1.24)	0.81 (0.65-1.01)
Model IV	1.07 (0.83-1.39)	0.96 (0.71-1.29)
High LDL–C		
Model I	0.68 (0.48-0.96) [a]	0.51 (0.34-0.78) [a]
Model II	0.70 (0.50-0.99) [a]	0.53 (0.35-0.81) [a]
Model III	0.72 (0.49-1.07)	0.43 (0.25-0.74)
Model IV	0.72 (0.49-1.07)	0.44 (0.26-0.72) [a]
High TC		
Model I	1.29 (0.98-1.70)	0.89 (0.64-1.24)
Model II	1.33 (0.99-1.75)	0.94 (0.67-1.32)
Model III	1.32 (0.97-1.79)	0.84 (0.57-1.23)
Model IV	1.32 (0.97-1.80)	0.86 (0.59-1.27)
High TG		
Model I	0.93 (0.72-1.19)	0.95 (0.73-1.24)
Model II	0.91 (0.71-1.17)	0.95 (0.72-1.24)
Model III	1.01 (0.86-1.33)	0.97 (0.71-1.32)
Model IV	0.97 (0.72-1.29)	1.03 (0.75-1.42)
Elevated FBG		
Model I	1.20 (0.99-1.45)	1.10 (0.90-1.36)
Model II	1.20 (0.98-1.44)	1.11 (0.90-1.36)
Model III	1.21 (0.97-1.50)	1.04 (0.82-1.32)
Model IV	1.21 (0.97-1.50)	1.04 (0.81-1.32)
Elevated blood pressure		
Model I	1.23 (0.95-1.60)	1.04 (0.77-1.41)
Model II	1.08 (0.82-1.40)	0.86 (0.63-1.17)
Model III	1.00 (0.74-1.35)	0.74 (0.52-1.06)
Model IV	1.02 (0.75-1.38)	0.81 (0.56-1.16)
Low HDL–C		
Model I	0.83 (0.71-0.97) [a]	0.85 (0.72-1.01)
Model II	0.80 (0.69-0.94) [a]	0.81 (0.68-0.96) [a]
Model III	0.83 (0.70-0.99) [a]	0.84 (0.69-1.01)
Model IV	0.83 (0.70-0.99) [a]	0.84 (0.70-1.02)
Metabolic syndrome		
Model I	1.26 (0.85-1.86)	1.18 (0.76-1.82)
Model II	1.16 (0.78-1.72)	1.00 (0.64-1.56)
Model III	1.96 (0.76-1.87)	1.00 (0.60-1.66)
Model IV	1.09 (0.67-1.78)	1.11 (0.64-1.90)

Rarely or never is reference in logistic regression analysis
Definition for overweight, obesity, abdominal obesity, cardiometabolic risk factors and metabolic syndrome are based on international definitions.[19–22] Model I:Without adjustment (crude model); Model II: Adjusted for age; Model III: Additionally adjusted for other characteristics including socio-economic status, family history of chronic disease, screen time; Model IV:Additionally adjusted for BMI in all abnormalities except for overweight and obesity.
a= Statistically significant or $P<0.005$

significant correlation between childhood obesity and dental caries.[37] As obesity is related to caries, hyposalivation, tooth loss, and periodontal diseases,[28] it is suggested that such dental problems could be used as markers of cardiometabolic risk.[38]

Tooth brushing is one of the most effective ways of preventing dental problems, which is established during the first years of life. Childhood obesity and dental caries have common contributing factors such as frequent snacking, nutritional habits, lifestyle pattern, and psychosocial issues.[39] However, in our study, we adjusted the role of obesity and socioeconomic status, and demonstrated the independent association of low frequency of teeth brushing with some cardiometabolic risk factors. This finding may suggest an independent association of poor oral health with increased risk of cardiometabolic risk factors from an early age. Actually, the importance of oral health and tooth brushing in the pediatric age group for prevention of cardiovascular diseases is generally limited to the preventive measures considered for prevention of endocarditis and other complications in those children and adolescents with congenital

heart diseases or other underlying diseases. Our findings underscore the importance of oral health and tooth brushing in all children and adolescents for prevention of future chronic diseases.

Study limitations and strengths

The major limitation of our investigation is its cross-sectional nature; thus, a causal relationship cannot be inferred from our findings and longitudinal studies are required to test for causality and the clinical importance of our findings. In this study, we could not examine the students' teeth and could not gather the data about oral hygiene status; however, we used tooth brushing as a marker for oral health. The main strengths of this study are its novelty in the pediatric age group, the large nationwide population studied, and adjustment for several confounding factors.

CONCLUSIONS

Our findings suggest an independent and inverse association of teeth brushing frequency with some cardiometabolic risk factors in adolescents. Prevention programs for primordial and primary prevention of non-communicable diseases should aim at both increasing the general health awareness and improving oral health.

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