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RESEARCH ARTICLE

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Passive smoking and cardiometabolic risk factors in Iranian children and adolescents: CASPIAN-V study

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Abstract

Background Smoking behavior as a harmful trend among adolescents and young adults has increased over last two decades. Many children and adolescents are at the risk of "second-hand" smoking at home due to their exposure to parents' or siblings' smoking. These second hand smokers are called "passive smokers" and are at risk of several health complications like cardiometabolic risk factors.

Objectives The present study aims to evaluate the association between passive smoking and increase of cardiometabolic risk factors in a sample of Iranian's children and adolescents, aged 7–18 years.

Methods This multicenter cross-sectional study was carried out over 14,400 students (aged 7–18 years). Blood sampling were randomly collected from a sub-sample of 4200 selected pupils. According to their degree of exposure to smoke for both cigarette and hookah, water pipes that are used to smoke specially made tobacco that comes in different flavors, all participants were divided to the two separate groups of positive and negative exposure. Metabolic syndrome (MetS) is defined as a constellation of at least three out of five cardiometabolic risk factors, including abdominal obesity, elevated blood pressure, elevated fasting plasma glucose concentration, high serum levels of triglycerides (TG), and depressed high-density cholesterol (HDL-C) levels.

Results The mean and standard deviation (SD) age of participants was 12.3 ± 2.24 years. 49.4% were girls and 71.4% of them were urban residents. The mean SD for BMI of participants was 18.5 (4.7) Kg/m2. The mean TG levels were considerably higher among passive smoker children and adolescents. MetS and being overweight were found to have a major association with passive smoking (OR 1.63 CI 95% 1.17–2.29 *P* Value 0.004 and OR 1.21 95% CI 1.06–1.37 P Value 0.004, respectively).

Conclusion This study confirms that passive smoking or second-hand smoking is linked with the increased prevalence of cardiometabolic risk factors and places children and adolescents at a higher risk of being overweight. Preventive strategies could be incorporated against passive smoking to recognize it as a health priority among children and adolescents.

Keywords Passive smoking · Cardiometabolic factors · Children and adolescents

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Introduction

According to a report released by World Health Organization (WHO) in 2009, Tobacco smoking leads to about five million deaths worldwide [1]. As a matter of regret, it is documented that 50% of the world's children (about 700 million) are exposed to tobacco smoke as the second hand smoke at home [2]. Passive smoking has been reported to have serious effects on children and adolescents because they are more vulnerable and more sensitive to the negative health outcomes of passive smoking compared to adults [3]. One of the most adverse effects of passive smoke among children and adolescents is the increased risk of cardio-metabolic risk factors [4, 5]. Our systematic review related to the direct link of abdominal obesity in children and adolescents with cardio-metabolic risk factors suggested that being passive smoke can be responsible for such health problems [6].

Cardio-metabolic risk factors are defined as the cluster of metabolic conditions including obesity, hyperglycemia, hyper-triglyceridemia, depressed high-density lipoprotein cholesterol (HDL-C) and elevated blood pressure (BP) which can significantly increase the risk of developing chronic diseases like cardiovascular diseases (CVDs) [7, 8]. Unfortunately, over the last decade the prevalence of cardio-metabolic risk factors has greatly increased in children and adolescents in developing countries [9, 10]. Despite the fact that recently some regulations are enforced against smoking in the public places, the number of children and adolescents exposed to harmful smoking has not decreased [11, 12]. These in danger groups are mostly exposed to dangerous toxic elements of tobacco at home.

The recent nationwide studies over the Iranian youth have revealed the prevalence rates of about 10% for cardiometabolic risk factors, which is much greater than other developed countries [13, 14]. The environmental tobacco smoke is associated with a wide range of negative health outcomes like childhood obesity, blood glucose abnormalities, and cardio-metabolic risk factors [15, 16]. In addition, some cohort studies have shown a dose-response association between tobacco smoke exposure and cardiometabolic risk factors in adolescents [17]. On the same basis, passive smoking can lead to adverse effects of endothelial function and increase the risk of atherosclerotic cardiovascular diseases (CVDs) [17, 18].

Regarding to the effects of metabolic syndrome (*MetS*) during the early years of a child's life, special consideration has been paid recently on the determining markers of *MetS* in the children and adolescents. The present study is the first report on the harmful impacts of exposure to smoke as the passive smoke and the risk of developing metabolic syndrome among a population of Iranian children and adolescents (aged 8–17 years).

Materials and methods

As a part of the Fifth national Iranian study [Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable Disease (CASPIAN-V)], the sampling and data collection of the present cross-sectional multi-centric study was conducted in 2015 covering both urban and rural areas of thirty Iranian provinces. The study protocol was mainly in accordance with the World Health Organization-Global School student Health Survey (WHO-GSHS). The inclusion criteria were having Iranian nationality and being aged between 8 and 17 years. The exclusion criteria were lack of chronic diseases like cancer and diabetes. Total numbers of 14,400 pupils of primary and secondary schools, aged 7–18 years were recruited whose parents were included in this research using a multistage, stratified cluster sampling method.

The number of male and female participants were the same in each province equal to 480 students (48 clusters of 10 students), and their ratio in urban and rural areas was proportional to the number of students in urban and rural areas. On the same basis, the number of samples between different grades in urban and rural areas was divided according to the number of students in each grade. The sample size required for the present study was achieved using cluster sampling in each province with equal cluster size. The final subgroup randomly selected for biochemical test was composed of 4200 students. This sample size was satisfactory since it could provide a good estimation of all risk factors undervaluation.

Data collection was done by two different questionnaires administered to collect information related to students and their parents. The student's questionnaire was obtained from the valid and reliable WHO-GSHS which was translated into Persian language [19, 20]. After sample saturation, the mission and purpose of the interview were explained to participants. The samples were explained that the questions are correlated to their health status and health-related behaviors. The students were asked to tell what they know, and frankly express if they do not distinguish something or are not sure about the answer. The parents of candidate students were also invited to complete the respective parent's questionnaire.

Passive smoking definition

Passive smoking is the inhalation of smoke which is called second-hand smoke (SHS) or environmental tobacco smoke (ETS) as well. In fact they are people who are not actively smoke but are relatives and siblings of an "active" smoker. We select the passive smoke through questioner and if the children have someone in their family who smoke cigarette or hookah (water pipes that are used to smoke specially made tobacco that comes in different flavors) selected as the passive smoke.

Physical measurements

An expert team of trained health-care researchers recorded the required information based on the approved checklists. The examinations were performed under standard protocols using calibrated instruments. Weight was measured on a scale placed on a flat ground to the nearest 0.1 kg while participants wearing a light cloth; and height was calculated with no shoes to the nearest 0.1 cm [19]. Body mass index (BMI) was recorded by dividing weight (kg) by height squared (m2) in accordance with WHO growth charts to categorize BMI [21]. Waist circumference was measure using an elastic tape at a point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration to the nearest 0.1 cm. Hip circumference was recorded at the widest part of the hip at the level of the greater trochanter to the nearest 0.1 cm [22]. Neck circumference was measured with an accuracy of 0.1 cm with the most prominent portion of the thyroid cartilage taken as a landmark. Blood pressure (BP) was measured in the sitting position on the right arm using a mercury sphygmomanometer with an appropriate cuff size. It was measured 2 times at 5 min intervals, and the average was recorded [23].

Physical activity and leisure-time screen time

To assess the youth's screen time (ST) behaviors, the participants were asked to record the number of hours per day during which they spent watching television (TV) and/or videos, personal computer, or electronic games, and accordingly the total cumulative time spent for ST was calculated.

Through a validated questionnaire, information regarding the rate at which they had physical activity during the past week as their leisure time outside the school was collected [20]. Having at least 30 min duration of exercises per day leading to sweating and large increases in breathing or heart rate was considered as enough physical activity.

Blood sampling

Eligible participants were referred to the laboratory while one of their parents accompanying them. Then, 6 ml venous blood sample was collected after 12 h overnight fasting. All collection tubes were centrifuged at 2500–3000×g for 10 min. Immediately, after centrifugation, serum samples were aliquoted into 200 μL tubes and stored at −70 °C. All samples were transferred by cold chain to Isfahan Mahdieh Laboratory. Fasting blood glucose, triglycerides (TGs), total cholesterol (TC), low-density lipoprotein-cholesterol (LDL-C) and high-density lipoprotein-cholesterol (HDL-C), alanine amino transferase, and creatinine were measured enzymatically by Hitachi Auto Analyzer (Tokyo, Japan) [24, 25]. The WHO growth curves were used to define BMI categories, i.e., underweight as age- and sex-specific BMI <5th, overweight as sex-specific BMI for age of 85th–95th, and obesity as sex-specific BMI for >95th. Waist-to-height ratio (WHtR) ≥ 0.5 was considered as abdominal obesity [26].

Also, we considered the fasting blood sugar ≥100 mg/dl, serum TGs ≥100 mg/dl, TC ≥200 mg/dl, LDL-C ≥ 110 mg/dl, and HDL-C < 40 mg/dl (except in boy 15–18 years mg/dl <45 mg/dl) as abnormal [27]. Elevated BP was defined as either high systolic BP values (≥90th percentile for age, sex, and height) or high diastolic BP values (≥90th percentile for age, sex, and height) [23].

Ethical concerns

Study protocols were reviewed and approved by ethical committees and other relevant national regulatory organizations. The Research and Ethics Council of Isfahan University of Medical Sciences approved the study (Project Number: 194049). Participation in the survey was voluntarily. Subsequent to complete justification of participants on objectives and study protocols, the students and parents were obtained verbal as well as written informed consent. All questionnaires and checklists were administered anonymously.

Statistical analysis

The mean (standard deviation (SD)) and number (percentage) were used to express continuous and categorical variables respectively. Student's t test was incorporated to compare mean of continuous variable across passive smoking groups. The association between qualitative variables was assessed by the Pearson's Chi-square test. Also, different logistic regression models were used to assess the association of passive smoking and cardiometabolic risk factors. In Model I, the crude association was assessed and in model II the association was adjusted for potential confounders including age, sex, sedentary time, physical activity, SES and residential areas, and in the model III, additionally BMI was adjusted for all abnormality except weight disorders (overweight, generalized and abdominal obesity). All statistical analysis was performed using survey data analysis methods. The STATA package version 11.0 (Stata Statistical Software: Release 11. Stata Corp LP. Package, College Station, TX, USA) was used to for data analysis purposes, and $P < 0.05$ was considered statistically significant.

Results

14,400 students were recruited in the present study. The participation rate for the whole study and for blood sampling was 99% and 91.5% (3843 out of 4200 students), respectively. The mean (SD) age of participants was

12.3 years, and the study population was consisted of 49.4% females and 50.6% males; 71.4% of students were urban and 28.6% were rural residents. Table 1 demonstrates students' characteristics and anthropometric measurements as per their passive smoking status,. The mean height of students was considerably higher in the passive smokers (*P* Value = 0.007). Both mother and father's education were found to be notably linked to the passive smoking (*P* Value 0.003 and < 0.001 respectively). There were no noteworthy relationship between positive family history of chronic diseases and passive smoking (*P* Value = 0.77). Passive smokers were identified to enjoy a higher socio-economic status (P Value <0.001). Physical activity and screen time were notably linked to passive smoking (*P* Value <0.001 and 0.02, respectively). Wrist Circumference was significantly higher among passive smokers (P Value = 0.02); however, no significant association was found between hip circumference and neck circumference with passive smoking (P Value 0.13 and = 0.07 respectively).

Mean TG was shown to be much higher among passive smokers compared to non-smoker ones (P Value = 0.03) (See Table 2).

Table 3 shows the frequency of the various cardiometabolic risk factors as per passive smoking status. MetS was higher in passive smokers and they were reported to have components of MetS more frequently. Although this study revealed that overweight was more common among passive smokers, no association was observed between low HDL-C, high LDL-C, high TG and high cholesterol.

In this regard, we incorporated special models in logistic regression analysis to assess the associations of passive smoking status with cardiometabolic risk factors and MetS. First, a crude model was practical without any adjustment. Model II was adjusted for age, sex, living area, socioeconomic status (SES), physical activity, screen time, positive family history of chronic diseases. In Model III, further adjustment was prepared for BMI for all risk factors except overweight and obesity. In crude analysis, overweight and MetS were significantly associated with passive smoking. Such associations were also reported while using Model II and Model III (Table 4).

Discussion

In this research, we evaluate passive smoking and the prevalence of cardiometabolic risk factors among a population of Iranian children and adolescents. The current study is entirely different from the CASPIAN V study conducted and published three years ago [28]. Because, here we revealed that passive smoking increases the risk of overweight and MetS in children. Several epidemiological studies have shown an increasing trend of overweight, obesity and MetS among youths [29–32]. As a matter of fact, the inhalation of tobacco smoke ends up in impaired endothelium-dependent vasodilatation (EDV) in macro vascular and micro vascular beds [33, 34]. Nitric oxide (NO) is principally responsible for the vasodilator function of the endothelium [35–37].

Atherosclerosis is a condition which develops as an inflammatory reaction. Exposure to smoke leads to raising raise of the peripheral blood leukocyte counts [38], and the level of multiple inflammatory markers including C-reactive protein, interleukin-6, and tumor necrosis factor alpha increase [39, 40]. Therefore exposure to smoke initiates the inflammation in the blood and the vessel wall. Moreover, inhaling cigarettes smoke possibly promote atherosclerosis, by affecting the lipid profile. Serum cholesterol, triglyceride, and low-density lipoprotein (LDL) are notably elevated in smokers compared to non-smokers, but the formers have higher levels of high-density lipoprotein (HDL) [41]. A substantial body of research have revealed that direct exposure to cigarette smoke leads to an increased oxidative modification of plasma LDL-C, which is pro-atherogenic and causes endothelial function [42].

The findings of present study are in line with other epidemiological research that have confirmed the association of passive smoking and increased risk of CVD among adults [43–46].

A major body of preceding literature has recognized association of active and passive smoking with MetS [47, 48]. As cited by previous literature, passive smoking has been shown to be significantly increased the cardiometabolic risk factors in adolescents. Passive smoker teenagers are more likely to be overweight and are shown to frequently suffer the components of MetS [49].

The present research has some limitations. Foremost, because of its cross-sectional design, establishing a causal association between passive smoking and cardiometabolic risk factors was not feasible. Longitudinal studies are extremely needed to investigate such an association and its clinical implications. The association between being second hand smokers and developing cardiometabolic risk factors might be confounded by ecological issues, lifestyle and genetic dissimilarities. The other limitation is that we incorporated self-reported data which may not be entirely accurate and precise.

Moreover, the samples are grouped based on their exposure positive and negative and the duration of their parents smoking was not considered. We did not consider the active smoking status of adolescents due to insufficient number of active smoker teenagers. Furthermore, our questionnaire did not take into account the period of exposure to tobacco, which can restrict the statistical analyses.

Table 1 Participants' demographic characteristics and cardiometabolic risk factors according to smoking status

	Passive smoking		
	No	Yes	P value
Age	12.24(3.15)	12.32(3.14)	0.14
Sex			0.43
-Girl	3760(56.94)	2843(43.06)	
-Boy	3808(56.26)	2960(43.74)	
Weight	41.17(17.01)	41.75(17.20)	0.05
Height	146.22(17.53)	147.04(17.38)	0.007
WC	66.61(12.13)	66.78(12.26)	0.42
WHtR	0.46(0.07)	0.45(0.06)	0.14
BMI-z score	−0.001(0.98)	009(1.00)	0.54
Region			0.91
-Urban	5386(56.57)	41.35(43.43)	
-Rural	2182(56.68)	1668(43.32)	
Father's education			<0.001
-Illiterate	936(57.25)	699(42.75)	
-Diploma/U	5220(54.84)	4299(45.16)	
-Academic	1137(64.64)	622(35.36)	
Mother's education			0.003
-Illiterate	1300(55.34)	1049(44.66)	
-Diploma/U	5371(56.26)	4175(43.74)	
-Academic	834(60.70)	540(39.30)	
Positive Family history of chronic diseases	3705(56.09)	2901(43.91)	0.77
Socio-economic status (%)			<0.001
-Low	2469(57.45)	1829(42.55)	
-Moderate	2253(53.30)	1974(46.70)	
-High	2510(58.99)	1745(41.01)	
Physical Activity			<0.001
-Low	2417(60.88)	1553(39.12)	
-Moderate	2317(54.89)	1904(45.11)	
-High	2431(55.95)	1914(44.05)	
Screen Time			0.02
-Low	6257(57.66)	4595(42.34)	
-High	1201(54.84)	989(45.16)	
Hip Circumference			0.13
-Low	3764(49.91)	2801(48.57)	
-High	3778(50.09)	2966(51.43)	
Wrist Circumference			0.02
-Low	3815(51.02)	2804(49.01)	
-High	3663(48.98)	2917(50.99)	
Neck Circumference			0.07
-Low	3814(50.71)	2832(49.15)	
-High	3707(49.29)	2930(50.85)	
Parental Waist Circumference	87.40(14.66)	87.76(14.82)	0.17
Parental BMI	26.38(4.78)	26.57(5.07)	0.03
Parental Obesity			0.48
-No	5849(78.50)	4437(77.99)	
-Yes	1602(21.50)	1252(22.01)	
Parental Over weight			0.57
-No	4603(61.78)	3542(62.26)	
-Yes	2848(38.22)	2147(37.74)	

BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; data are mean (SD)

Table 2 Comparison of participants' mean (SD) blood pressure, lipid profile and serum glucose level according to smoking status

	Passive smoker		
	No	Yes	P value
SBP, mmHg	99.03(12.85)	99.41(13.29)	0.11
DBP, mmHg	63.99(10.42)	63.67(10.48)	0.08
LDL-C, mg/dl	89.81(22.51)	90.10(22.89)	0.72
HDL-C, mg/dl	46.06(9.84)	46.17(10.17)	0.74
TC-C, mg/dl	153.29(27.16)	154.32(27.78)	0.26
TG, mg/dl	87.15(43.88)	90.39(47.42)	0.03
FBS, mg/dl	91.95(13.27)	91.34(10.77)	0.14

P < 0.05 = significance. HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride; TC, total cholesterol; FBS, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure

The strengths of the study were its novelty in targeting children and adolescent's age group, its nationwide coverage, which included a great representative sample size, the population-based approach of the survey, and proceeding according to the standard protocols and a validated questionnaire [50, 51] as well as adjustment of the statistical analyses for the main confounding factors.

Table 3 Frequency of adolescents' cardiometabolic risk factors according to smoking status

	Passive smoker		
	No	Yes	P value
Overweight	673(8.95)	577(10.03)	0.04
General obesity	887(11.79)	632(10.98)	0.15
Abdominal obesity	1584(21.07)	1178(20.53)	0.44
Elevated LDL-C	363(17.72)	265(17.02)	0.62
Elevated TC	100(4.88)	75(4.84)	0.95
Elevated TG	555(27.09)	455(29.34)	0.14
Low HDL-C	600(29.28)	474(30.56)	0.41
Elevated FBG	76(3.71)	74(4.77)	0.11
Elevated BP	846(11.38)	676(11.85)	0.41
MetS (+)	84(4.22)	96(6.34)	0.005
No. of MetS components:			0.04
0	786(39.50)	563(37.16)	
1	727(36.53)	539(35.58)	
2	393(19.75)	317(20.92)	
3	79(3.97)	87(5.74)	
4	5(0.25)	9(0.59)	

P < 0.05 = significance. HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; TG, triglycerides; TC, total cholesterol; FBG, fasting blood glucose; BP, blood pressure; MetS: metabolic syndrome. Cardiometabolic risk factors were defined according to the Adult Treatment Panel III criteria modified for children and adolescentss, as follows: overweight, body mass index BMI age- and sex-specific 85–95th percentile; general obesity, BMI higher than age- and sex-specific 95th percentile; abdominal obesity, waist–to-height ratio > 0.5; low HDL-C, <50 mg/dl (except in 15–19-year-old boys in whom the cut-off was <45 mg/dl); elevated LDL-C, >110 mg/dl; elevated TG, >100 mg/dl; elevated TC, >200 mg/dl; elevated FBG, >100 mg/dl; elevated BP, >95th (adjusted for age, sex and height)

Table 4 Association between smoking status and cardiometabolic risk factors in different models of logistic regression analysis

		Passive smoker		
		OR	95% CI	P value
Overweight	Model I	1.13	1.01–1.27	0.04
	Model II	1.21	1.06–1.37	0.004
General obesity	Model I	0.92	0.83–1.03	0.15
	Model II	0.90	0.80–1.02	0.09
Abdominal obesity	Model I	0.97	0.89–1.05	0.44
	Model II	1.00	0.91–1.1	0.97
Elevated LDL-C	Model I	0.96	0.80–1.14	0.62
	Model II	0.95	0.78–1.14	0.57
	Model III	0.95	0.78–1.15	0.57
Elevated TC	Model I	0.99	0.73–1.35	0.95
	Model II	0.97	0.69–1.35	0.84
	Model III	0.98	0.70–1.37	0.89
Elevated TG	Model I	1.12	0.97–1.29	0.14
	Model II	1.18	1.00–1.38	0.05
	Model III	1.17	0.99–1.37	0.06
Low HDL-C	Model I	1.06	0.92–1.23	0.41
	Model II	1.02	0.87–1.20	0.80
	Model III	1.01	0.86–1.19	0.90
Elevated FBG	Model I	1.30	0.94–1.80	0.12
	Model II	1.16	0.82–1.65	0.41
	Model III	1.14	0.80–1.62	0.46
Elevated BP	Model I	1.05	0.94–1.17	0.41
	Model II	1.06	0.94–1.19	0.35
	Model III	1.06	0.94–1.20	0.32
MetS (+)	Model I	1.54	1.14–2.07	0.005
	Model II	1.62	1.17–2.25	0.004
	Model III	1.63	1.17–2.29	0.004

Model I: crude model; Model II: adjusted for age, sex, living area, SES, physical activity, screen time, positive family history of chronic diseases; Model III: additionally adjusted for BMI in all abnormality except the weight disorders

Conclusion

This study recognized that the passive smoking is associated with MetS and being overweight in adolescents. Children and adolescents are exposed to tobacco smoke at home and other outer environments. To address this important public health concern, healthcare providers need to promote anti-tobacco regulations for public places and in the home.

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Contributors Mehdi Ebrahimi, Ramin Heshmat, and Roya Klishadi are main investigator of this study. Mohammadreza Hashemi Aghdam, and Faeze Abbaspour Kaboodan wrote the manuscript. Mostafa Qorbani analyses the data, Fatemeh Khatami edited the manuscript after reviewer comments, Gita Shafiee, Zeinab Ahadi, Mohammad Esmaeil Motlagh, Hasan Ziaodini, Majzoubeh Taheri were taking part in questionnaire completing.

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Compliance with ethical standards

Conflict of interest All authors declare that there is not any kind of conflict of interests.

Ethics approval Participation in the survey was voluntary. The participants entered the survey after explaining the study objectives and protocols and obtaining oral assent from students and written consent from their parents. The research ethics committee of the Endocrine and Metabolism Research Center (EMRC) from Tehran University of Medical Sciences and ethics boards of Isfahan University of Medical Sciences approved the study protocol. All questionnaires and checklists were completed anonymously.

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