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Association of Exposure to Fine Particulate Matter and Risk Factors of Non-Communicable Diseases in Children and Adolescents

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Abstract

Background: Risk factors of non-communicable disease (NCD) origin from early life, and exposure to environmental pollutant may be a predisposing factor. This study aimed to investigate the association of air quality index (AQI) and fine particulate matter ($PM_{2.5}$) with some NCD risk factors in a sample of Iranian children and adolescents.

Materials and Methods: This cross-sectional study was conducted in 2014 to 2016 among children and adolescents, aged 6-18 years, in Isfahan, Iran. Physical examination, including weight, height, and blood pressure, was conducted by standard methods. Fasting blood sample was obtained for fasting blood glucose, total cholesterol, high density lipoprotein-cholesterol, low-density lipoprotein-cholesterol, and triglycerides. The mean AQI and $PM_{2.5}$ values from the study time till one year prior to the survey were used. Multiple linear regression analysis was conducted for the association of AQI and $PM_{2.5}$ with other variables.

Results: Participants consisted of 186 children and adolescents with mean (SD) age of 10.52(2.38) years. Exposure to higher level of $PM_{2.5}$ had significant associations with higher levels of systolic blood pressure, low-density lipoprotein cholesterol, and triglycerides. It also had positive relationship with other risk factors and inverse association with low-density lipoprotein cholesterol (LDL-C), but these associations were not statistically significant. The corresponding figures were not significant for AQI.

Conclusion: At current study results showed that exposure to higher levels of fine particulates was associated with some NCD risk factors in children and adolescents. Early life prevention of NCDs can lead to large reductions in disease risk; adverse effects of ambient pollutants should be considered in this regard.

Key Words: Adolescents, Air pollution, Blood glucose, Blood pressure, Children.

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1- INTRODUCTION

Growing body of evidence exists on developmental origins of health and disease regarding various factors related to the origins of non-communicable diseases (NCDs) from early life. The interaction of various factors including epigenetics; gene-environment interaction; fetal programming; socioeconomic status; dietary and physical activity habits; active and passive smoking, as well as environmental factors including air pollution result on the development and progress of NCDs (1-3). Similar to many other developing countries (4), NCDs risk factors are prevalent in Iranian pediatric population (5), therefore the underlying factors need to be determined for future preventive programs.

It is documented that in adults ambient air pollution might increase the risk of major NCDs including diabetes mellitus (6), cardiovascular diseases (7), and cancers (8). Studies have shown that in the pediatric population, exposure to tobacco smoke is associated with NCD risk factors (9, 10); however, such experience is limited on the association of ambient pollutants with NCD risk factors. Available studies showed that exposure of healthy children and adolescents to air pollutants, notably particulate matter (PM), is associated with increases in blood pressure (BP), heart rate, arterial stiffness, systemic inflammation, oxidative stress, insulin resistance, and endothelial dysfunction (11-13).

Although NCD risk factors are more frequent in children and adolescents with excess weight; however they are not found in all obese individuals and on the other hand, some normal-weight persons might have NCD risk factors(14,15). Therefore, in addition to genetic and lifestyle factors, the role of environmental factors should be considered as well. In recent years, more attention have been paid to the role of ambient air pollutants on risk factors of chronic diseases in the pediatric age group. This study aimed to investigate the association of air quality index (AQI) and fine PM ($PM_{2.5}$) with some NCD risk factors in a sample of Iranian children and adolescents.

2- MATERIALS AND METHODS

2-1. Study Participants

This cross-sectional study was conducted from October 2014 to March 2016 among 186 children and adolescents, aged 6-18 years, who lived in Isfahan, the most industrialized city in Iran. By distributing invitation letters, participants were randomly selected from households living in different areas of the city, where the seven air monitoring stations were located. By considering an alpha error of 0.05 and a power of 80%, and a previous study on the differences of the children's lipid profile according to the air quality of the living area (16), the sample size was calculated as 150; by considering possible missing data we increased it to 200.

The eligibility criteria consisted of being aged 6-18years, living for at least 12 months in urban areas of Isfahan city with air pollution monitoring stations. Those individuals who had a history of active smoking, exposure to household tobacco smoke, chronic disease, or long-term medication use were not included in the study.

2-2. Ethical consideration

The study was approved in the Research Council and Ethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran (Project number: 193042). It was conducted after obtaining written informed consent from the parents and oral assent from participants, aged 6-18.

2-3. Study Area

Isfahan is the most industrial area in Iran, with a population of near 2 million, located in the center of Iranian plateau. The air of this city is predominantly affected by industrial emissions and motor traffic.

2-4. Data collection and physical examination

Participants were invited to the clinic affiliated to the Research Institute for Primordial Prevention of Non-communicable Disease, Isfahan University of Medical Sciences. Trained physicians and nurses conducted the physical examination under standard protocols and by using calibrated equipment. Weight was recorded in light clothing to the nearest 0.1 kg on a SECA digital weighing scale (SECA, Germany), and height was measured without shoes to the nearest 0.1 cm. Body mass index (BMI) was calculated by dividing weight to height squared (kg/m^2).

Two measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were performed using a standardized mercury sphygmomanometer on the right arm after a 15-minute rest in a sitting position; the first and fifth Korotkoff sounds were recorded as systolic and diastolic BP, respectively. The mean of the two measurements was considered as the subject's blood pressure (17). A validated questionnaire was completed by interview. It consisted of questions regarding demographic information as well as dietary and physical activity habits. Information of the previous week physical activity was collected. Having physical activity was considered as exercises with at least 30 minutes duration per day, and that led to heavy sweating or large increases in breathing or heart rate. Based on this provided definition, participants described their weekly Physical activity (PA) habits through three available response choices as follow; none, 1-2 days, 3-6 days, and every day. For statistical analysis, each weekly frequency categorized into three groups; less than two times per week (Low), two to four times a week (Moderate) and more than 4 times a week (High). Daily consumption of various foods were recorded for participants. Foods with high nutritional value including fruits, vegetables and milk were considered as healthy foods (18).

2-5. Air quality data

The air quality index (AQI) is used to describe the level of air pollution with adverse health effects. It includes five major air pollutants: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. AQI values above 100 are considered to be unhealthy for sensitive groups including children, and its higher values are harmful for the whole population. PM is a complex mixture of extremely small particles and liquid droplets in the air; those with a diameter of 2.5μm are known as fine PM ($PM_{2.5}$). When inhaled, these particles would affect various organs by causing short-term and long-term health effects (19).

Data on the AQI and $PM_{2.5}$ were obtained from the Isfahan Department of Environment, which is a governmental organization, and collects data from the seven air pollution-monitoring sites of the city by using the same standards and equipment. In addition, we used ambient air particulate sampler PQ200 in parallel for $PM_{2.5}$ sampling at various stations to compare the results with the data of the monitoring stations for assessing the consistency and interchangeability of two field sampling methods. The mean AQI and $PM_{2.5}$ values from the study time till one year prior to the survey were used in this study.

2-6. Laboratory analysis

A 12-hour-fasting venous blood sample was obtained for biochemical tests. Fasting blood glucose (FBG), total cholesterol (TC), high density lipoprotein-cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG) were measured enzymatically by

Hitachi 704 *autoanalyzer (Hitachi, Tokyo, Japan).*

2-7. Statistical analysis

Continuous variables are presented as mean± standard deviation (SD) and categorical variables as number (percent). Multiple logistic regression was used to explore the association of AQI and PM2.5 with presence of NCD risk factors. Age (years), gender, BMI, daily consumption of healthy foods, and physical activity was included as potential confounders in the model. Statistical analyses were performed with IBM SPSS Statistics (version 22.0). The significance level was set at P<0.05.

3- RESULTS

Data of 186 children and adolescents were complete (93% participation rate); they had mean (SD) age of 10.52 (2.38) years. The number of recruited participants ranged between 23 to 27 people in each area of the city near air monitoring stations. The variables studied are shown in **Table.1**.

Table.2 presents the results of multiple linear regression analyses on the association of AQI and fine PM with NCD risk factors after adjustment for potential confounding factors. It shows that higher level of $PM_{2.5}$ had significant associations with higher levels of SBP, Low density lipoprotein cholesterol (LDL-C), and Triglycerides (TG). It also had positive relationship with other risk factors and inverse association with HDL-C, but these associations were not statistically significant. Higher levels of AQI had positive associations with all risk factors except than with HDL-C (that had inverse association), but these correlations were not statistically significant.

Table-1: Characteristics of participants, laboratory and air quality data (n=186)

Variables		Statistics
Age (year)		10.52 (2.38)
Gender	Boys (%)	79 (42.5%)
	Girls (%)	107 (57.5%)
BMI (kg/m^2)		20.57 (4.37)
SBP (mmHg)		96.65 (4.70)
DBP (mmHg)		67.56 (5.31)
Daily eating healthy foods (%)	Fruits	104 (55.9%)
	Vegetables	116 (62.4%)
	Milk	94 (50.5%)
Daily physical activity (%)	Low	68 (36.6%)
	Moderate	97 (52.2%)
	Vigorous	21 (11.3%)
FBG (mg/dL)		88.76 (9.72)
T.Chol (mg/dL)		151.74 (40.83)
LDL-C(mg/dL)		92.02 (24.95)
HDL-C(mg/dL)		50.18 (12.40)
TG (mg/dL)		101.10(52.98)
AQI		101.59(4.52)
$PM_{2.5}$		47.16(2.72)

Values are mean± standard deviation (SD) for continuous variables and number (relative frequencies) for categorical variables. Abbreviations: BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; FBG: fasting blood glucose; T.Chol: total cholesterol; LDL-C: low density lipoprotein-cholesterol; HDL-C: high density lipoprotein-cholesterol; TG: triglycerides; AQI: air quality index; PM2.5: particulate matter with diameter of less than 2.5µm.

Table-2: Correlation coefficient (Beta) of the multiple linear regression analyses of the air quality index and fine particulate matter with risk factors of non-communicable diseases in children and adolescents

Environmental indexes	Models	BMI	SBP	DBP	FBG	T.Chol	LDL-C	HDL-C	TG
AQI									
	Model 1	0.32	0.36	0.24	0.21	0.31	0.27	-0.21	0.35
	Model 2		0.34	0.27	0.18	0.27	0.31	-0.24	0.31
$PM_{2.5}$									
	Model 1	0.34	0.47*	0.21	0.22	0.38	0.45*	-0.27 0.51*	
	Model 2		0.41*	0.24	0.25	0.35	0.46*	-0.28	0.48*

Note: The numbers in the table present the correlation coefficients (as mentioned in the title of this table); those correlations that were significant ($P<0.05$) are marked by asterisk (*). Model.1: adjusted for age and gender; Model.2: adjusted for age, gender, body mass index, diet and physical activity. Abbreviations: BMI: body mass index(Kg/m^2); SBP: systolic blood pressure(mmHg); DBP: diastolic blood pressure(mmHg); FBG: fasting blood glucose(mg/dL); T.Chol.: total cholesterol(mg/dL); LDL-C: low density lipoprotein-cholesterol (mg/dL); HDL-C: high density lipoprotein-cholesterol (mg/dL); TG: triglycerides(mg/dL); AQI: air quality index; PM2.5: particulate matter with diameter of less than 2.5μm.

4- DISCUSSION

This study aimed to investigate the association of exposure to ambient pollutants with some NCD risk factors in a sample of Iranian children and adolescents. It showed that exposure to elevated fine particulate matter was associated with some risk factors, namely SBP, LDL-C and TG. These associations were not strong, but they might be considered as predisposing factors for future chronic disease in the young population studied.

Several studies in adults documented that environmental pollutants should be considered among predisposing factors for NCDs. Some recent meta-analyses revealed the association of exposure to ambient pollutants with diabetes mellitus (1, 22, 23, 24). Some other reviews confirmed the association of exposure to ambient pollutants with other NCDs including cardiovascular and respiratory diseases (24-27), as well as with some types of cancers (28, 29). Such experience is limited in the pediatric population, but growing evidence showed that exposure to ambient pollutants, notably fine PM, is associated with NCD risk factors in children and adolescents (30, 35). The mechanisms linking air pollution and NCD risk factors mainly consist of systemic inflammation, oxidative stress, reduced insulin sensitivity as well as elevated arterial stiffness and BP (31-33). Some of these underlying changes related to the effects of particulate air pollution on NCD risk factors, mainly cardiometabolic impairment, are documented in the pediatric age group (16, 36, 37). Primordial and primary preventive programs are more likely to be effective at preventing NCDs than population screening programs that would identify the early stages of only after the disease is already established (1, 2).

Given the global burden of NCDs, and their origins from early life, various scientific organizations have underscored the need to address NCD risk factors across the whole of life, from fetal period into older age. The strategy of the World Health Organization and the United Nations highlighted the necessity of preventing NCDs and their risk factors in children and adolescents (38). Likewise, in his message for 2017, the president of the American Academy of Pediatrics considered NCD confronting as a priority for pediatricians. He said "*I call on pediatricians to take part in a multi-sectorial approach that includes education and cultural change to confront non-communicable disease. During the 20th century, mortality in children was concentrated in those younger than 5 and resulted mostly from infections and vaccine-preventable diseases. The 21st century brought us an understanding that hypertension, obesity, emphysema, coronary heart disease and a large number of cancers are preventable conditions that begin to develop during childhood; We can help reverse this*" (39).

There is now convincing evidence from human epidemiological studies and animal experiments to support the hypothesis that exposure of children and adolescents to environmental conditions may predispose them to an increased risk of NCDs in later life. Evidently, understanding and preventing the environmental factors that contribute to the rise in NCDS is of crucial importance. They should be considered in different health policy programs including the school-based primary NCD risk reduction plans (40).

4-1. Study limitations and strengths*:*

The child's habit and socio- cultural context that can influence the pain experience of children and was not controllable in the present study.

5- CONCLUSION

We found that exposure to higher levels of fine particulates was associated with some NCD risk factors in children and adolescents, regardless of some potential confounders. Early life preventive measures against NCDs can lead to large reductions in disease risk; adverse effects of ambient pollutants should be considered in this regard. Further studies are necessary in this regard, especially in those populations with both ethnic predisposition to NCDs and high exposure to environmental contaminants.

6- CONFLICT OF INTEREST: None.

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