Environmental Toxicology and Pharmacology 58 (2018) 156–162

Contents lists available at ScienceDirect

Environmental Toxicology and Pharmacology

journal homepage: www.elsevier.com/locate/etap

# Long-term high air pollution exposure induced metabolic adaptations in traffic policemen

Chaochao Tan, Yupeng Wang, Mingyue Lin, Zhu Wang, Li He, Zhiyi Li, Yu Li, Keqian Xu*

*Department of Laboratory Medicine, Xiangya School of Medicine, Central South University, Changsha 410013, P.R. China*

ARTICLE INFO

*Keywords:*
Air pollution exposure
PM2.5
Metabolic adaption
Traffic policeman
Conventional laboratory tests

ABSTRACT

*Objective:* To assess the adverse physiological changes induced by long-term exposure to PM2.5.
*Methods:* Totally 183 traffic policemen and 88 office policemen as the control group, were enrolled in this study. The concentrations of PM2.5 in both the working places of traffic and office policemen were obtained. Detailed personal questionnaires and conventional laboratory tests including hematology, fasting blood glucose, blood lipids, liver, kidney, immunity and tumor-related markers were conducted on all participants of this study.
*Results:* A dose-response relationship between the FBG, HDL-c and CEA values and the PM2.5 exposure duration was observed. Multivariate analysis confirmed that one hour on duty outdoor per day for one year was associated with an increase in FBG of 0.005% (95% CI: 0.0004% to 0.009%), CEA of 0.012% (95% CI: 0.006% to 0.017%), and a decrease in HDL-C of 0.001% (95% CI: 0.00034% to 0.002%).
*Conclusion:* Long-term high air pollution exposure may lead to metabolism adaptation and it is likely involved in the development of cardiovascular disease and diabetes mellitus.

## 1. Introduction

Fine particle matters with aerodynamic diameters ≤ 2.5 μm (PM2.5) have been well documented as the major air pollutants harmful to human health and the leading risk factors for various disease including cancer, coronary and peripheral vascular disease, diabetes, stroke and respiratory diseases (Brunekreef et al., 2009; Chen et al., 2013; Cohen et al., 2017; Dehbi et al., 2017; Minelli et al., 2011; Peters et al., 2001; Raaschou-Nielsen et al., 2013; Xie et al., 2015). However, most epidemiological and clinical studies merely focused on the association of PM2.5 concentrations with disease mortality and morbidity, the exposure duration, physiological changes and underlying mechanisms have rarely been addressed. Moreover, current evidences on physiological response and adverse physiological effects induced by PM2.5 exposure remains largely unexplored.

PM2.5 has been established as a major threat to human health that could impair the biological functions of most human organs. However, little is known about the relationship between air pollution exposure and general health such as their effects on hematology, renal, hepatic parameters. Biomarkers, as primary indicators in pathologic processes, could be potentially applied for the evaluation of harmful biologic changes caused by exposure to PM2.5 (Tan et al., 2017; Yang et al., 2017). Furthermore, epidemiological studies have demonstrated that the duration of pollutant exposure, long-term or short-term exposure, produces huge difference in the adverse physiological changes and health effects (Xiao et al., 2016). But, few investigations have addressed the health effects and adverse physiological changes caused by long-term exposure to PM2.5.

PM2.5 refers to the complex mixture of heavy metals, microorganisms and numerous known carcinogens. The source, composition and concentration of PM2.5 components vary vastly, thus producing substantial context-dependent variation in its adverse physiological changes (Bandowe et al., 2014; Fracasso et al., 2010; Zhai et al., 2014). It has been widely recognized that PM2.5 concentration in China has been maintained at levels much higher than most of Europe and North America, and the source and composition of PM2.5 in China are also quite different(Bandowe et al., 2014; Zhang and Cao, 2015). Thus, the conclusion of most previous studies about the health effects and underlying physiological mechanisms obtained from other countries cannot be simply applied to the Chinese population exposed to higher PM2.5 pollution with distinct composition.

The traffic policeman is one special population with the highest exposure to air pollution in city for professional reasons in China. Due to the high population density and rapid increase of vehicle number in

*Abbreviations:* BMI, body mass index; FBG, fasting blood glucose; HDL-c, high-density lipoprotein cholesterol; LDL-c, low-density lipoprotein cholesterol; TG, triglyceride; TB, total bilirubin; ALT, alanine aminotransferase; TP, total protein; ALB, Albumin; BUN, urea nitrogen; Cr, creatinine; UA, uric acid; CEA, cancer embryo antigen; AFP, alpha fetal protein; ESR, erythrocyte sedimentation rate; ASO, antistreptolysin "O"; RF, rheumatoid factor; RBC, red blood cell; Hb, hemoglobin

* Corresponding author.
*E-mail address:* xukeqian@csu.edu.cn (K. Xu).

https://doi.org/10.1016/j.etap.2018.01.002
Received 26 October 2017; Accepted 4 January 2018
Available online 05 January 2018
1382-6689/ 

China, policemen are more vulnerable to air pollution due to continuous exposure to vehicular emissions while standing for long hours at intersections of main roads. Clinical conventional laboratory tests including hematology, fasting blood glucose, blood lipids, liver, kidney, immunity and tumor-related biomarkers are less expensive and helpful to fully understand adverse physiological changes. Therefore, it is rational to use conventional laboratory tests to characterize the health outcomes and specific adverse physiological changes caused by air pollution exposure, which would provide deep insights into the biological basis and pathological mechanisms of air pollution-associated diseases.

## 2. Material and methods

### 2.1. Study population and research design

Totally 183 male traffic policemen who have been working long-time in the main road intersections of Changsha city were enrolled in this study as the exposure group. Another 88 male policemen working in the police station as office clerks were enrolled as the control group. All participants should have worked as policemen for more than one year, at the age of less than 60 years and without history of heart disease, hepatitis, cancer and kidney disease and extra exposure to carcinogen before. Samples from each participant were collected following the standard operation and all the procedures were finished.

For evaluating the influence of exposure extent, the exposure group was further classified into the short-term, medium-term and long-term exposure groups according to their duty time at highly polluted main road intersections. Before sample collection, personal information including individual characteristics, working experiences (years of service and average outdoor duty time per year), as well as several potential cofounders including smoking, alcohol-drinking, diet, exercise and medication, were obtained by a detailed questionnaire from each participant. Informed consent was signed by each participant, and the study process was approved by the Ethics Committee for Research of Central South University and performed following the Code of Ethics of the World Medical Association (Declaration of Helsinki).

### 2.2. Exposure degree evaluation

The average PM2.5 concentration of Changsha city, the intersections of main roads and the police station offices were monitored by the Bureau of Environmental Protection of Changsha and our study group using TEOM RP-1400a or portable DUSTTRAK 8532 particle monitor. The cumulative intersection duty time was used as the indicator of traffic policemen's air pollution exposure extent. The following formula was applied for the calculation: Number of cumulative intersection duty time (hours) = (number of working hours/day) × (Number of working days/week) × 50 (weeks/year) × Number of service years.

### 2.3. Physical examination and blood sample collection

To guarantee the reliability of the following tests, comprehensive physical examination of each participant, including body mass index (BMI) and systolic and diastolic pressure, was performed by experienced clinicians in the Health Center affiliated to the Third Xiangya Hospital of Central South University, Changsha, China. One tube of EDTA blood sample was collected for routine hematologic tests, and another two tubes of anticoagulant-free fasting blood were then collected for laboratory analyses immediately after being centrifuged for 10 min at 1500*g*.

### 2.4. Laboratory analyses

For investigation of physiological effects of air pollution, conventional laboratory tests including routine blood examination, clinical chemistry test and the tumor biomarkers CEA and alpha-fetoprotein were performed using the blood samples of each participant after the physical examination. First, the WBC, RBC, platelet count and hemoglobin (Hb) level were measured using a Sysmex SE 9000 analyzer (Sysmex, Japan). Fasting blood glucose (FBG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), triglyceride (TG), total protein (TP), total bilirubin (TB), alanine aminotransferase (ALT), albumin (ALB), urea, creatinine (Cr) and uric acid (UA) levels in serum were measured immediately using a HITACHI 7600-020 Biochemical Analyzer (HITACHI, Japan). Then, the IgA, IgM, IgG, antistreptolysin "O" (ASL) and rheumatoid factor (RF) levels in serum were determined using an BN™II automatic protein analyzer (Siemens, Germany). Cancer embryo antigen (CEA) and alpha fetal protein (AFP) levels were analyzed by the automatic chemiluminescence immunoassay analyzer (LIAISON XL, Birkenfeld, Germany).

### 2.5. Statistical analysis

The statistical analysis of data in this study was carried out using a SPSS19.0 software (SPSS, USA). The independent sample *t*-test (normally distributed continuous variables), the Mann-Whitney U (not normally distributed variables) or the chi-square test (categorical variables) was used for comparison between the exposure group and the control group. The statistical model was adjusted for the potential confounders including age, BMI, education level, marriage, fruit, vegetable, meat, smoking, drinking and exercise by multiple linear regression. The Analysis of Variance test(normally distributed continuous variables), the Mann-Whitney *U* test (not normally distributed variables) or the chi-square test (categorical variables) was applied for statistical comparison of the control, short-term, medium-term and long-term exposure groups. The Spearman correlation test was performed for analyzing the correlation between air pollution exposure level and the RBC, Hb, Cr, FBG, HDL-c, CEA and IgG levels. Furthermore, multiple linear regression analysis was performed using FBG, HDL-C and CEA as the dependent variables and all these potential confounders age, BMI, education degree, marriage status, meat, fruit, vegetable, smoking, drinking and physical exercise as independent variables. Statistical significance was defined by a two-sided P value of $< 0.05$.

## 3. Results

### 3.1. Atmospheric data of Changsha City

Changsha is the capital city of the Hunan province located in southeast China. The pollutant PM2.5 of Changsha was mainly from vehicular emission, fuel combustion, resuspension of dust and other pollution sources. As shown in the yearly distribution of air pollution in Changsha, the nitric oxide level exhibited no decrease in past years due to the drastic increase of vehicle number(Fig. 1).

Considering that the traffic policemen were the community with high susceptibility to vehicle exhaust, the study of traffic policemen would reasonably provide inspirational insight into the health effects of air pollution. We found that the average PM2.5 concentrations of the intersections of main roads($132.4 \pm 48.9\,\mu g/m^3$) was 2.61 times higher than the police station offices($50.80 \pm 38.6\,\mu g/m^3$).

### 3.2. Descriptive statistics of study population

The statistics of the study population were shown in Table 1. Most traffic policemen were exposed to long-term traffic exhaust with a median average duration of 7.00 years (ranges from 2.00 to 23.00 years), and the average cumulative outdoor duty time reached 8030 h (ranges from 1000 to 38000 h). In our study, we observed that the levels of RBC, hemoglobin, albumin, urea, creatinine, FBG and CEA in the