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Exposure to polycyclic aromatic hydrocarbons and central obesity enhanced risk for diabetes among individuals with poor lung function

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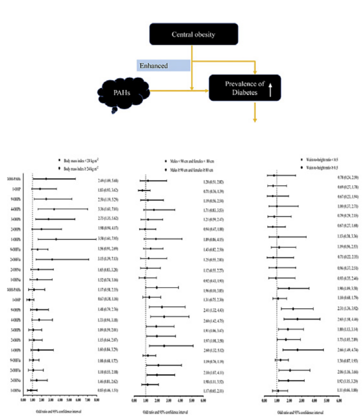
HIGHLIGHTS

- Urinary OH-PAHs was positively related to diabetes in central obesity individuals.
- No additive effect of urinary ΣOH-PAHs and central obesity on diabetes was found.
- Central obesity, high ΣOH-PAHs and poor lung function increased risk for diabetes.

GRAPHICAL ABSTRACT



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ABSTRACT

Some studies have shown an association between obesity or exposure to polycyclic aromatic hydrocarbons (PAHs) and the risk of diabetes. This study aimed to investigate the interaction of obesity and urinary monohydroxy-PAHs (OH-PAHs) on diabetes. Individuals (n = 2716) were drawn from the baseline survey of the Wuhan-Zhuhai Cohort Study. They completed the physical examination,

Abbreviation: AP, attributable proportion due to interaction; BMI, body mass index; CRP, C-reactive protein; LOD, limits of detection; MET, metabolic equivalent; OR, Odd ratios; PAHs, polycyclic aromatic hydrocarbons; RERI, the relative excess risk due to interaction; WC, waist circumstance; WHtR, waist-to-height ratio; 1-OHNa, 1-hydroxynaphthalene; 2-OHNa, 2-hydroxynaphthalene; 2-OHFlu, 2-hydroxyfluorene; 9-OHFlu, 9-hydroxyfluorene; 1-OHPh, 1-hydroxyphenanthrene; 2-OHPh, 2-hydroxyphenanthrene; 3-OHPh, 3-hydroxyphenanthrene; 4-OHPh, 4-hydroxyphenanthrene; 9-OHPh, 9-hydroxyphenanthrene; 1-OHP, 1-hydroxypyrene; 95% CI, confidence interval.

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measurements of lung function, biochemical indices and urinary OH-PAHs levels. Additive effect of obesity and urinary ΣOH-PAHs levels on diabetes was assessed by calculating the relative excess risk due to interaction (RERI) and the attributable proportion (AP) due to interaction. Several urinary OH-PAHs were positively associated with diabetes in individuals with central obesity or normal weight ($p < 0.05$ for all). Among individuals with poor lung function, the RERI between urinary ΣOH-PAHs and waist circumstance (WC, RERI: 0.866, 95% CI: −0.431, 2.164, $p = 0.192$) or waist-to-height ratio (WHtR, RERI: 1.091, 95% CI: −0.124, 2.305, $p = 0.078$) was found; the AP due to the interaction between urinary ΣOH-PAHs and WC or WHtR was 0.383 (95% CI: −0.07, 0.80, $p = 0.086$) or 0.465 (95% CI: 0.019, 0.912, $p = 0.04$). The results indicated that central obesity may enhance the effect of exposure to background PAHs on diabetes in individuals with poor lung function.

1. Introduction

Abdominal obesity was a stronger risk factor for developments of many diseases such as metabolic syndrome, insulin resistance, type 2 diabetes, hypertension, dyslipidemia (Matsuda and Shimomura, 2013). The worldwide prevalence of obesity has almost doubled since 1980. Especially, the prevalence of abdominal obesity (clinically known as central obesity) has been increasing substantially. For instance, in China, the prevalence of abdominal obesity in men and women changed from 8.5 to 27.8% and 27.8–45.9%, respectively, during the period of 1993–2009 (Xi et al., 2012). Moreover, the prevalence of diabetes increase in parallel with the increased prevalence of abdominal obesity, showing an increase from 9.7% to 11.6% during the period of 2007–2010 (Xu et al., 2013). Accumulated evidence indicated that adults with abdominal obesity are at a higher risk of the development of diabetes (Xue et al., 2016). Waist-to-height ratio (WHtR) and waist circumstance (WC) as indicators reflecting abdominal obesity are better anthropometric indices than body mass index (BMI) for predicting the risk of arterial stiffness and subclinical atherosclerosis (Recio-Rodriguez et al., 2012).

Literature showed that inflammatory response and oxidative stress mediate adverse obesity-related outcomes. Moreover, persistent low-grade systemic inflammation in relation to abdominal obesity may contribute to developing of insulin resistance and metabolic disorders (Esser et al., 2014). Epidemiologic study showed that elevated C-reactive protein (CRP) was associated with increased risk of diabetes (Wang et al., 2013), thus, systemic inflammatory markers were used to predict the development of diabetes in the general population (Esser et al., 2014). Obesity, especially of visceral fat obesity, play a key role in the pathogenesis of certain diseases such as insulin resistance, diabetes, hypertension, dyslipidemia and cancer (Matsuda and Shimomura, 2013). One underlying mechanism for obesity-associated diseases (such as diabetes and atherosclerosis) might be oxidative stress (Matsuda and Shimomura, 2013). Because reduction of diabetes-induced oxidative stress and insulin resistance showed certain beneficial effects on prevention or treatment of diabetes, which was related to age-associated metabolic dysfunction (such as diabetes and insulin resistance) (Styskal et al., 2012).

Polycyclic aromatic hydrocarbons (PAHs) are persistent organic pollutants. They are released from the domestic burning of coal and wood, tobacco and cooking oil fume (Kim et al., 2013). Experimental study showed that chronic exposure to PAHs could increase the risk of type 2 diabetes by inducing production of proinflammatory cytokines (Khalil et al., 2010). Besides, elevated levels of inflammatory cytokines were found among individuals with high PAHs exposure (Alshaarawy et al., 2013). Moreover, elevated levels of urinary monohydroxy-PAHs (OH-PAHs) were associated with increased risk for diabetes in US adults and Chinese general population (Alshaarawy et al., 2014; Yang et al., 2014), and chronic exposure to PAHs induced oxidative stress, which was involved in the development of diabetes (Maritim et al., 2003; Kuang et al., 2013). Additionally, additive effect of reduced lung function and urinary OH-PAHs on diabetes was also found (Hou et al., 2016).

The present study examined the effect modification by obesity indices (including WC, WHtR and BMI) on the association of exposure to background PAHs with the risk of diabetes. All data were sourced from the baseline survey of the Wuhan-Zhuhai Cohort Study.

2. Materials and methods

2.1. Study population

Based on 3053 Wuhan residents aged from 18 to 80 years in Wuhan for at least 5 years from the baseline survey of the Wuhan-Zhuhai Cohort Study (Song et al., 2014), 2716 Wuhan individuals were finally included in this study, after exclusion of individuals with no information on lung function parameters ($n = 61$), BMI ($n = 36$), urinary OH-PAHs levels ($n = 246$), blood biochemical indices ($n = 10$), family history of diabetes ($n = 16$) and WC ($n = 52$).

The questionnaire was used to collect information from each individual on the demographic characteristics (such as age, gender and educational levels), occupational history, lifestyle (including active and passive smoking, leisure-time physical activity status and self-cooking meals) as well as personal and family medical histories by the trained interviewers. The definitions of smoking and drinking status, leisure-time physical activity and poor lung function were same as described in our previous work (Hou et al., 2016). Briefly, nonsmokers were defined as those who had smoked less than one cigarette per day in the past six months, otherwise, they were done as smokers. Passive smokers were defined as those who exposed to tobacco smoke indoor environment at least once a week for at least 15 min each time. Nondrinkers were defined as those who had drunk alcohol less than once each week in the past six months; otherwise, they were done as drinkers. Metabolic equivalent (MET) -min per week was calculated (MET coefficient of activity × duration (min per time) × frequency (times per week)) according to the compendium of physical activities described in elsewhere (Ng et al., 2009; Ainsworth et al., 2011). More than 600 MET-min per week was defined as leisure-time physical activity, otherwise was done as leisure-time physical inactivity (Hallal et al., 2012). Poor lung function included at least obstructive lung dysfunction and restrictive lung dysfunction (Mannino et al., 2003, 2005). Obstructive lung dysfunction was defined as forced