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Association between serum concentrations of persistent organic pollutants and smoking in Koreans: A cross-sectional study

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ABSTRACT

Background: Studies on the associations between persistent organic pollutants (POPs) and smoking according to gender and smoking amount (cigarettes/day) are limited, and the results regarding the relationship between POPs and smoking are not completely consistent across studies.

Objectives: The smoking rate in Korea is one of the highest among the Organization for Economic Cooperation and Development (OECD) countries. We investigated the association between serum concentrations of POPs and cigarette smoking in Koreans by smoking status (never-smoker/ever-smoker) and smoking amount (cigarettes/day) according to gender.

Methods: Serum concentrations of 32 polychlorinated biphenyls (PCBs) and 19 organochlorine pesticides (OCPs) were measured in 401 participants (232 men and 169 women) who received health examinations during the Korean Cancer Prevention Study-II. We compared POP levels in ever-smokers and never-smokers and conducted multivariate logistic regression analyses to identify associations between POPs and smoking.

Results: Among women, the concentrations of PCB 156, PCB 167, and PCB 180 were significantly higher in ever-smokers than in never-smokers. After adjustments for age, body mass index, gamma-glutamyl transpeptidase, and alcohol intake, serum PCB 157 concentration was positively associated with male ever-smokers (OR 2.26; 95% CI, 1.01–5.04). In addition, *trans*-nonachlordane in OCPs as well as PCBs was significantly positively related with female ever-smokers (OR 3.21; 95% CI, 1.04–9.86). We found that subjects who smoked fewer than 15 cigarettes/day had a higher risk of having high POP concentrations than never-smokers.

Conclusions: These results indicate that smoking may be associated with human serum POPs levels.

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1. Introduction

Persistent organic pollutants (POPs), including polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs), are chemical substances that persist in the environment and accumulate in adipose tissue.^{1,2} Many studies have suggested that POPs may increase health risks.² Therefore, to decrease the risks of high body burden, many countries are trying to eliminate or restrict POPs through legal regulations. Bioaccumulation through the food chain and intake of food are known as major exposure factors for POPs.^{3–5}

However, it has been reported that smoking may also affect POP concentrations.⁶

Some scientists have studied the influence of smoking on POP levels in humans, but the results have been inconsistent.^{7–10} In a study based on samples of Swedish males, CB-153, and p,p'-DDE was correlated with smoking when 2000 and 2004 data were pooled.¹⁰ Also, Fierens et al. reported that serum dioxin levels in male smokers were higher than in male non-smokers, while serum dioxin concentrations of female smokers were lower than female non-smokers.⁷ In a review study, it was reported that seven studies published between 1980 and 1995 reported that smoking was not associated with levels of organochlorines, while five studies published in a similar period (1985–1994) reported that smoking was correlated with concentrations of organochlorine residues.⁸ In addition, another review study suggested that the associations

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between POPs and smoking were different by district.⁹ Furthermore, in an epidemiologic study based on samples of male Inuit in Greenland, smoking was an important determinant of POP bioaccumulation.¹¹ In a epidemiologic study using NHANES data, smoking increased the mortality of subjects with high serum POP levels. However, Jain and Wang found that the levels of polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans (PCDD/PCDF) were significantly lower in smokers than in nonsmokers.¹²

In studies of populations in East-Asian countries, it has been reported that PCDD/F levels were higher in nonsmokers and passive smokers than in active smokers among Taiwanese¹³ and that maternal smoking history was associated with a decrease of POP concentrations among Japanese.¹⁴ Despite the fact that Korea has banned most OCPs since 1969, several OCPs were still detected in Korean human samples. In addition, the level of OCPs was higher than has been reported in several other countries.¹⁵

The smoking rate of Korean men was the highest among the OECD countries in 2012. In addition, the smoking rate of Korean women was the lowest among the OECD countries in 2012 but has been increasing continuously.¹⁶ Therefore, it is necessary to determine the accumulation of POPs by smoking amount in Koreans. To our knowledge, a study on the associations of POPs and smoking aimed at the Korean population has not yet been conducted. Also, studies analyzing the associations between POPs and smoking according to gender and smoking amount are scarce.

The purpose of this study was to investigate the associations between serum concentrations of POPs and cigarette smoking among Koreans by smoking status and smoking amount according to gender.

2. Materials and methods

2.1. Study population

The study population was selected from the Korean Cancer Prevention Study-II (KCPS-II). KCPS-II included 270,514 individuals

who visited 21 health examination centers in the Seoul and Gyeonggi districts of Korea from April 1994 to December 2013. In the process of health examination, a researcher who was educated about Institutional Review Board (IRB) requirements explained the KCPS-II and received a signed written consent form from participants. In total, 159,844 participants provided a signed written consent form.^{17,18} Of these, 1,050 subjects with anthropometric data (height, weight, and body mass index [BMI]), blood test information (total cholesterol, high-density lipoprotein cholesterol [HDL-C], triglyceride, and gamma-glutamyl transpeptidase), self-reported questionnaire information (age, smoking status, smoking amount, and alcohol intake) obtained during the health examination and POPs values obtained during 2013–2014 were eligible.^{17,18} We excluded 601 participants with prostate cancer, breast cancer, or stroke, 44 participants who were missing body mass index (BMI) values or smoking status, and 4 participants who had outlying values for OCPs ($\geq 1,000$ ng/g lipid). Thus, the final study subjects consisted of 401 participants (232 men and 169 women) aged 21–73 years who had health examination from 2001 to 2011 (Fig. 1).

This study was approved by Yonsei University Health System, Severance Hospital, Institutional Review Board (Approval Number 4-2013-0119).

2.2. Measurements

In the collected blood samples, total-cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglyceride, and gamma-glutamyl transpeptidase were measured. Weight and height were measured in light clothing after the participants removed their shoes.¹⁸

Information on cigarette smoking (smoking status and smoking amount [cigarettes/day and packs/year]) and alcohol intake was obtained from self-reported questionnaires. Packs/year was calculated as smoking amount (cigarettes/day) divided by 20 (cigarettes/pack) and multiplied by smoking period.¹⁹

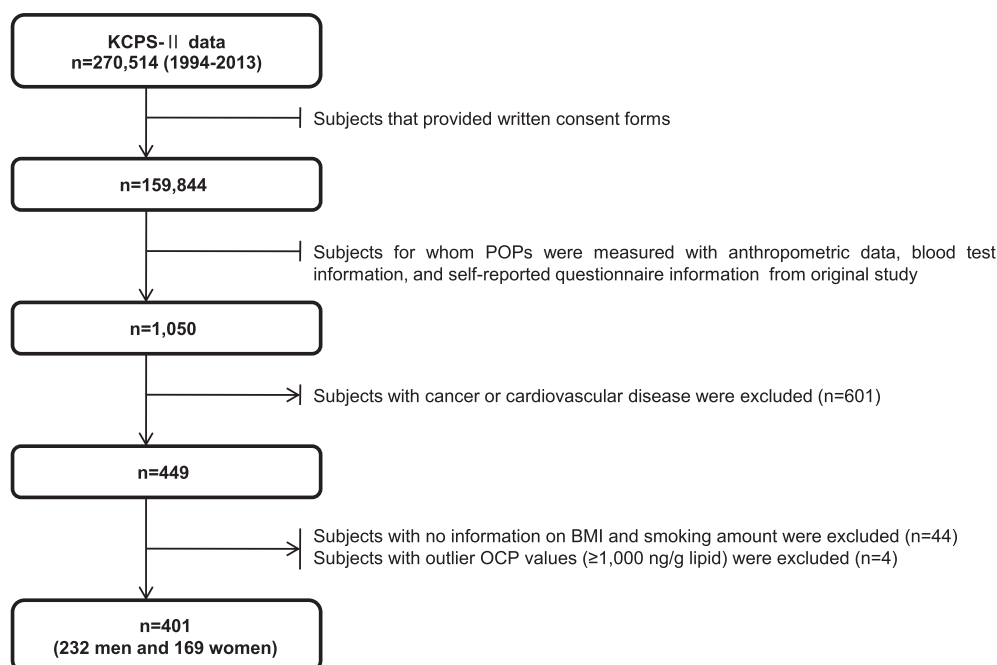


Fig. 1. Flow chart for selection of the study population. KCPS, Korean Cancer Prevention Study; POPs, persistent organic pollutants; OCPs, organochlorine pesticides.

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