EXPOSURE OF KOREAN POPULATION TO BISPHENOL A IN URINE: RESULTS FROM THE KOREAN NATIONAL ENVIRONMENTAL HEALTH SURVEY (KNEHS) 2009-2011

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Introduction

Bisphenol A (BPA) is used in the manufacture of polycarbonate plastic and epoxy resins, which are used in canned food, protective coatings on food containers, and dental sealants. Most human exposure is believed to be via ingestion and consumer products.[1-2] The health effects of BPA in humans have been reported liver damage, thyroid hormone disruption and reproductive toxicity.[3-5] Human Biomonitoring (HBM), as a nationwide population respective study on human exposure to environmental chemicals, was conducted in Europe and the USA.[6-7] Human exposure data from HBM are useful for evaluating the internal levels of environmental chemicals among the general population and support the environmental health policy to reduce exposure to environmental pollution.

In Korea, the Korean National Survey for Environmental Pollutants in the Human Body (KorSEP) as a pilot study was conducted from 2005.[8] By the announcement of the Environment Health Act (article 14), the Korean National Environmental Health Survey (KNEHS) as a nationwide study launched in 2009. The purpose of KNEHS is to identify the human exposure status to environmental contaminants and help assess the environmental health policies to reduce exposure to chemicals. Also, the results of the survey will be announced as national statistics every 3 years. The present report aims to determine the representative values for urinary BPA levels in the Korean population, with the distribution by potential exposure factors.

Materials and methods

The KNEHS was conducted by the National Institute of Environmental Research in Korea. This survey used the stratified sample design to monitor representative concentration of environmental chemicals. The KNEHS consisted of 350 sampling locations, including urban, rural, and coastal areas, and regions adjacent to air quality monitoring networks. A total of 6,311 participants aged 19-88 years were investigated from 2009 to 2011 and 6,266 were eligible for these analyses after exclusion of subjects without urine sample.

All participants answered questionnaires regarding sociodemographic information, the indoor and outdoor environments, lifestyle and food consumption. Spot urine specimens (80mL) were collected for the measurement of BPA and creatinine in a urine specimen cup. Urinary BPA was analyzed using a method high-performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS).[9]

The detection level of 0.240ug/L was achieved, sufficient for measuring urinary BPA levels in non-occupationally exposed participants.

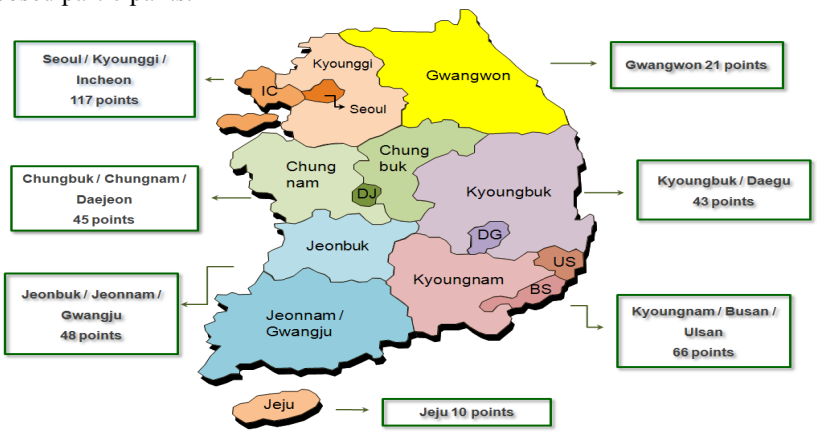

Fig1. Sampling locations of KNEHS 2009-2011

BPA concentrations below the limit of detection (LOD) were assigned a value of LOD/√2 prior to adjustment by creatinine.[10] Creatinine was measured using an automated colorimetric determination based on the reaction of creatinine and picric acid first reported by Jaffé.[11] Data analysis was conducted using SAS procedure SURVEYMEANS (SAS version 9.3; Cary, NC), which uses the sample weight and calculates variance estimates to adjust for the unequal probability of selection into the survey.

Results and discussion

Urinary BPA concentrations were measured in 6,266 samples of the total KNEHS 2009-2011 participants.

Table1. Characteristics of the participants in this study

	Sample size	%
Total	6,266	100
Gender		
Male	2,911	46.5
Female	3,355	53.5
Age (years)		
19-29	739	11.8
30-39	1,175	18.8
40-49	1,331	21.2
50-59	1,485	23.7
60-69	1,105	17.6
≥70	431	6.9
Residence area		
Rural	4,939	78.8
Urban	422	6.7
Coastal	177	2.8
Air monitoring	728	11.6
Smoking status		
Non-smoker	4,856	77.5
Smoker	1,408	22.5

Table 1 shows the characteristics of the participants in this study. A total of 6,266 participants, including 2,911 males (46.5%) and 3,355 (53.5%) females were investigated. Participants ranged in age from 19 to 88 years and 77.5% of the participants were non-smokers. There were two missing data in the Questionnaires regarding smoking status.

Table 2 shows the selected percentiles of urinary BPA concentrations by gender, age, residence area and smoking status. Levels of urinary BPA were evaluated based on the volume of urine (ug/L) and adjustment by creatinine (ug/g creatinine). Creatinine concentration was used to validate the spot urinary samples according to the guideline of the World Health Organization (0.3g/L≤creatinine≤3.0g/L).

The population-weighted geometric mean (GM) of BPA concentrations was 0.748ug/L (95% CI, 0.707-0.791) and the level of males was 0.811ug/L, higher than that of females (0.691ug/L). Urinary concentrations were highest in those aged 19-29 (0.903ug/L) and, 30-39 (0.903ug/L), and decreased with age. The GM of BPA (0.787ug/L) and the population 95 percentile (8.352ug/L) of the coastal area were higher than other areas.

Table2. Arithmetic and geometric means and selected percentiles of urinary BPA (ug/L) concentrations for the Korean population

	AM	GM (95% CI)	Percentiles (95% CI)				Sample size
			25th	50th	75th	95th	
Total ug/L	1.76	0.748(0.707-0.791)	0.307	0.704	1.561	5.865	6,266
ug/g creatinine	1.84	0.884(0.838-0.933)	0.409	0.832	1.700	5.992	5,668

Gender							
Male	1.95	0.811(0.760-0.867)	0.343	0.760	1.660	6.468	2,911
Female	1.58	0.691(0.646-0.739)	0.270	0.652	1.460	5.282	3,355
Age (years)							
19-29	2.02	0.903(0.803-1.015)	0.380	0.917	1.840	6.713	739
30-39	2.05	0.903(0.823-0.990)	0.409	0.834	1.843	6.740	1,175
40-49	1.59	0.755(0.690-0.827)	0.320	0.721	1.564	5.780	1,331
50-59	1.47	0.654(0.604-0.708)	0.249	0.625	1.326	5.208	1,485
60-69	1.29	0.595(0.545-0.649)	0.220	0.555	1.224	3.872	1,105
≥70	2.07	0.552(0.470-0.649)	0.190	0.452	1.111	4.613	431
Residence area							
Rural	1.77	0.753(0.711-0.798)	0.310	0.710	1.567	5.865	4,939
Urban	1.52	0.664(0.504-0.874)	0.255	0.600	1.392	6.138	422
Coastal	1.98	0.787(0.594-1.043)	0.296	0.850	1.830	8.352	177
Air monitoring	1.54	0.695(0.592-0.816)	0.260	0.680	1.460	5.110	728
Smoking status							
Non-smoker	1.71	0.727(0.686-0.771)	0.300	0.690	1.523	5.634	4,856
Smoker	1.93	0.813(0.742-0.892)	0.330	0.760	1.745	6.520	1,408

Urinary BPA concentrations of smokers (0.813ug/L) were higher than that of non-smokers (0.727ug/L). But, there was not a significant correlation between urinary BPA levels and these factors.
The mean of urinary BPA levels in the general Korean population (0.75ug/L for 19 years and older) was lower than that in American (1.99ug/L for 20 years and older) and Canadian population (1.16ug/L for 6-79 years). Also, the population 95 percentile (RV95, 5.87ug/L for 19 years and older) was lower than the reference value (RV95, 13.2ug/L for 20 years and older) by NHANES. Males had higher urinary BPA levels than females did in this study, similar to other reports.[7, 12-13]

In this study, we present the geometric means of the urinary BPA and geographical exposure status in the Korean population. We also identify the distribution of several factors including gender, age and smoking status. In the future study, we will define the vulnerable group and the high exposure group and conduct an in-depth research for high risk areas and factors using these results. The second survey (2012-2014) is currently underway starting from June 2012.

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References
1. Vandenberg. LN, Hauser R, Marcus M, Olea N, Welshons WV. (2007), *Reprod Toxicol*. 24(2): 139-177
2. Kang JH, Kondo F, Katayama Y. (2006). *Toxicology*. 226(2-3): 79-89
3. Bindhumol V, Chitra KC, Mathur PP. (2003). *Toxicology*. 188(2-3): 117-124
4. Moriyama K, Tagami T, Akamizu T, et al. (2002). *J Clin Endocrinol Metab*. 87(11): 5185-5190.
5. Ikezuki Y, Tsutsumi O, Takai Y, Kamei Y, Taketani Y. (2002). *Hum Reprod*. 17(11): 2839-2841
6. Schulz C, Seiwert M, Babisch W, et al. (2012). *Int J Hyg Environ Health*. 215: 435-448
7. CDC. Fourth National Report on Human Exposure to Environmental Chemicals. (2012). Available from: www.cdc.gov/exposurereport/pdf/FourthReport-updatedTables_Mar2013.pdf.(accessed March 2013)

8. Lee JW, Lee CK, Moon CS, et al. (2012). *Int J Hyg Environ Health*. 215(4): 449-57
9. Ye X, Kuklenyik Z, Needham LL, Calafat AM. (2005). *Anal Chem*. 77(16): 5407-5413
10. Hornung RW, Reed LD. (1990). *Appl Occup Environ Hyg*. 5: 46-51
11. Jaffé M. (1886). *Z Physiol Chem*. 10: 391-400
12. Haines DA, Murray J. (2012). *Int J Hyg Environ Health*. 215: 133-137
13. Health Canada, Report on Human Biomonitoring of Environmental Chemicals in Canada. (2010). Available from: www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/chms-ecms/index-eng.php.(accessed 08.04.11)