Original Article

Association between Phthalate Exposure and the Use of Plastic Containers in Shanghai Adults*

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Abstract

Objective Consuming phthalates may be due to the presence of food contact materials, such as plastic containers. In this study, we investigated the association between plastic container use and phthalate exposure in 2,140 Shanghai adults.

Methods Participants completed a questionnaire on the frequency of using plastic containers in different scenarios in the previous year (e.g., daily, weekly) and on the consumption of plastic-packaged foods in the previous three days (yes or no). Urinary phthalate metabolites were used to assess the association between phthalate exposure and the use of plastic containers.

Results The metabolites of di-(2-ethylhexyl) phthalate (DEHP) were the most frequently detected in urine. The results revealed that phthalate exposure was associated with consumption of plastic-packaged breakfast or processed food items in the previous three days. The consumption of these two food items had strong synergistic effects on increasing urinary concentrations of most phthalate metabolites.

Conclusion Our results of plastic-packaged breakfast and processed food may be explained by the use of flexible plastic containers, indicating the importance of risk assessment for the application of flexible plastic containers.

Key words: Phthalate exposure assessment; Food contact materials; Flexible plastic containers; Plastic-packaged breakfast; Plastic-packaged processed food

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INTRODUCTION

Safety concerns about phthalates are on the rise due to their iniquitousness and association with a variety of health outcomes[1-2], including allergies, obesity, atherosclerosis, and asthma[3-6]. Phthalates, which are diesters of 1,2-benzenedicarboxylic acid, belong to a class of synthetic compounds used in multiple consumer and industrial products[7], such as automotive plastics, cosmetics, personal care and cleaning products, and food packaging[8-10]. Phthalates are not chemically bound to the raw materials of these products [e.g., polyvinyl chloride (PVC)] and can easily leach from the products into food, air, and other environmental media[10-11].

Diet is considered as significant exposure pathway for phthalates[12-19], especially di-(2-ethylhexyl)

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phthalate (DEHP), which is present in several food items such as poultry, meat, cream, eggs, and fish[19]. A few cross-sectional studies performed in the United States have reported that di-ethyl-phthalate metabolites are associated with vegetable consumption, while high-molecular-weight phthalate metabolites and DEHP are positively associated with meat and poultry intake[12,20]. Even though diet is a major exposure source for phthalates, the exact mechanism by which phthalates enter the food chain is not clear[11]. One possible mechanism is that food contact materials (FCMs) (e.g., plastic containers, lids, can linings, dishware utensils) used in the manufacturing, processing, storage, and transportation of foods contain phthalates[21]. Human exposure to phthalates migrated from FCMs have been paid much attention recently. Many countries, such as the United States, European countries, Japan, and China, set a maximum level for some phthalates migrated from FCMs[22]. Although FCMs were identified as one source, whether or how FCMs lead to increased exposure of phthalates remains unclear. Several studies have attempted to lower phthalate exposure through carefully designed dietary interventions (limited usage of FCMs), although the results were inconsistent[23-24].

Phthalates are mainly used as plasticizers to increase the flexibility of plastics. Phthalates account for 90% of plasticizer consumption in China (> 0.87 million per year)[25]. Plastics are the main raw materials of most FCMs. China has banned the use of PVC in FCMs by recommending the replacement of PVC with polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET)[26]. Although phthalates are predominantly used in PVC, their potential use or contamination in other polymers has been previously suggested. Shen (2005) looked into a variety of polymers, including PVC, Polystyrene (PS), PE, and cellulose-based polymers and PE laminates, and identified phthalates in 24 out of the 25 plastic samples[27]. It is possible that the plastic FCMs may release phthalates into the foods no matter what polymers the FCMs were made of.

Despite the well-known suspect of plastic FCMs to the dietary exposure of phthalates, there is lack of study discussing whether and how FCMs contribute to the phthalate exposure. Generally, people do not know what types of polymer are in the plastic FCMs, but can try to limit their use of FCMs. Since the 2011 Taiwan food scandal[28], great concern on phthalates has been raised in China. Some people have limited the use of plastic products in their daily life. Yet such behavior does cause an inconvenience. A better choice is to understand the phthalate exposure coming from which scenarios and which products (e.g., plastic containers). By avoiding such scenarios, people may reduce their phthalate exposure without disturbing their daily life.

In this study, we tried to link the use habits of plastic containers (one type of FCMs) in human daily life with urinary concentrations of phthalate metabolites. The hypothesis is that if certain types of plastic containers are contaminated with phthalates, then in the scenarios in which people frequently use such containers in their daily life, the phthalate excretions in urine will increase. The characteristics of the containers will help us understand how phthalate exposure occurs through the use of FCMs.

MATERIALS AND METHODS

Study Population and Sampling

The study participants were from the Shanghai Food Consumption Survey (SHFCS), which was conducted from September 2012 through August 2014. The SHFCS has been described in detail in a previous report[29]. In the first interview (autumn 2012) of the SHFCS, participants from 22 communities (the SHFCS contained 25 communities) were required to complete a questionnaire on the use frequency of plastic containers by trained investigators, and provided one spot urine sample during the investigation. Among the 3,322 participants of the SHFCS, 3,082 provided spot urine samples. After the exclusion of 278 participants for lacking data on the use of plastic containers, 89 participants for lacking weight or height information, 326 without enough volume of the urine sample for detecting phthalate metabolites, 25 for unreasonable creatinine concentration (< 20 μmol/L or > 30,000 μmol/L), and 224 aged ≤ 18 years, 2,140 participants with ages > 18 years had complete information of use of plastic containers and phthalate metabolites. All participants provided informed consent before their participation in the SHFCS.

Use of Plastic Containers

We designed a questionnaire to assess the use of plastic containers. In the present study, plastic containers referred to routine plastic products that were used to package or store food, including plastic