Environmental Research 166 (2018) 340–343

Contents lists available at ScienceDirect

Environmental Research

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

Assessment of exposure to air pollution in children: Determining whether wearing a personal monitor affects physical activity

Stephanie Lovinsky-Desir[a,*], Jennifer Lawrence[b], Kyung Hwa Jung[b], Andrew G. Rundle[c], Lori A. Hoepner[d,e], Beizhan Yan[f], Federica Perera[d], Matthew S. Perzanowski[d], Rachel L. Miller[b,d,g], Steve N. Chillrud[f]

[a] Division of Pediatric Pulmonology, Department of Pediatrics, College of Physicians and Surgeons, Columbia University, 3959 Broadway CHC-745, New York, NY 10032, United States
[b] Division of Pulmonary, Allergy and Critical Care of Medicine, Department of Medicine, College of Physicians and Surgeons, Columbia University, PH8E-101, 630W. 168th St., New York, NY 10032, United States
[c] Department of Epidemiology, Mailman School of Public Health, Columbia University, 722W. 168th St., New York, NY 10032, United States
[d] Department of Environmental Health Sciences, Mailman School of Public Health, Columbia University, 722W. 168th St., New York, NY 10032, United States
[e] Department of Environmental and Occupational Health Sciences, State University of New York, Downstate School of Public Health, Box 43, 450 Clarkson Ave., Brooklyn, NY 11203, United States
[f] Lamont-Doherty Earth Observatory, Columbia University, 61 Rt, 9W Palisades, NY 10964, United States
[g] Division of Pediatric Allergy, Immunology, and Rheumatology, Department of Pediatrics, College of Physicians and Surgeons, Columbia University, PH8E-101, 630W 168th St., New York, NY 10032, United States

ARTICLE INFO

Keywords:
Activity
Wearing compliance
Air pollution
Microaeth
Accelerometer
Compliance
Exposure equipment
Device

ABSTRACT

Personal air pollution monitoring in research studies should not interfere with usual patterns of behavior and bias results. In an urban pediatric cohort study we tested whether wearing an air monitor impacted activity time based on continuous watch-based accelerometry. The majority (71%) reported that activity while wearing the monitor mimicked normal activity. Correspondingly, variation in activity while wearing versus not wearing the monitor did not differ greatly from baseline variation in activity (P = 0.84).

1. Introduction

Early air pollution exposure assessments were limited to fixed sampling for a region using large or bulky portable samplers (Vincent, 2012). In recent years microelectronics and small pumps have emerged allowing investigators to sample an individual person's exposure (Vincent, 2012). The closer we get to assessing actual personal exposure, the better we can evaluate true associations between air pollution and health (Koehler and Peters, 2015). Personal samplers can capture the spatial and temporal variability that exist in all visited microenvironments and activity-related exposures (e.g. personal cloud); thus, contributing to greater accuracy in associating exposures to physiological outcomes (Koehler and Peters, 2015). However, the nature of personal samplers is that in order to capture accurate measurements they should be worn consistently and not change behavior. This is critical for people of all ages who may be susceptible to modified behavior while engaging in research studies, including children.

Exposure to ambient pollutants, including black carbon (BC), a component of fine particulate matter $< 2.5\,\mu m$, is one of the leading risk factors for morbidity and mortality globally (Lim et al., 2012). It is important to measure particulate concentrations in the breathing zone, duration of exposure, and volume of air inhaled to precisely calculate the individual level concentration of exposure (Davies and Whyatt, 2014). The inhaled dose of pollution potentially can be amplified with physical activity due to increased respiratory rates and larger tidal volumes (Oravisjarvi et al., 2011; Rodes et al., 2012). Thus, personal air pollution sampling combined with minute ventilation measurements can yield a more accurate inhaled pollutant dosage. However, exposure measurements under testing conditions, may not reflect real-life exposure if activity is altered while wearing the monitor. Therefore, it is important to determine if and how much a study participant's behavior is altered by wearing the device.

* Corresponding author.
E-mail address: sl3230@cumc.columbia.edu (S. Lovinsky-Desir).

https://doi.org/10.1016/j.envres.2018.06.017
Received 27 February 2018; Received in revised form 15 May 2018; Accepted 8 June 2018

Our objective was to determine if personal air pollution exposure monitoring changed usual physical activity levels in a cohort of 9–14 year-olds living in an urban environment. Additionally, we aimed to determine characteristics that may be associated with differences in activity while wearing personal exposure equipment. We hypothesized that the amount of time children engaged in moderate to vigorous activity (MVA) on days when they were asked to wear an exposure monitor would not differ significantly from usual fluctuations in day-to-day activity.

2. Materials and methods

Children ages 9–14 years (n = 163) were recruited for a nested study within the Columbia Center for Children's Environmental Health longitudinal birth cohort of African Americans and Dominicans in New York City (NYC) (Jung et al., 2017; Perera et al., 2003). Enrollment criteria for the nested parent study included age within the predefined range (9–14 years) and diagnosis of asthma (target of 56% asthmatics). To measure personal exposure to BC, for 24-h periods participants carried a 280 g, battery operated MicroAeth (Model AE51, AethLabs, San Francisco, CA) within a vest pocket with the inlet tube coming out of the double lined vest at the breathing zone (Supplemental Fig. 1) (Cai et al., 2013). An accelerometer (ActiCal, Phillips Respironics, Bend, OR) was attached to the MicroAeth to verify when it was being moved/worn. Children could remove the vest while sleeping, bathing, and during vigorous activity if it was uncomfortable (Lovinsky-Desir et al., 2014). Also, children wore a wrist-mounted accelerometer with a hospital band (could only be removed by cutting off) during the entire 24-h BC weekday-monitoring period and for 5 consecutive days thereafter (Lovinsky-Desir et al., 2014). Questionnaires were administered immediately following BC monitoring to assess the child's experiences while wearing the exposure vest (Supplemental Table 1).

Based on the wrist-mounted accelerometer, total time spent in MVA was calculated for the 24-h BC monitoring period (herein after referred to as 'vest day') and compared to the subsequent 24-h weekday when the child was not wearing the MicroAeth ('non-vest day') (Supplemental Fig. 2). To assess natural variation in day-to-day MVA without wearing the vest, we defined 'baseline' variation as non-vest day MVA compared to 24-h of weekend MVA. We chose a weekend day for comparison because the deployment schedule resulted in having more complete data for a weekend day without wearing the vest (100%) than for a second non-vest weekday (2%) (Supplemental Fig. 2).

Data were analyzed for 142 children with complete wrist based accelerometer data (n = 21 missing). Sign ranked tests were used to compare time spent in MVA on: 1. vest vs. non-vest days, 2. baseline variation (non-vest weekday vs. weekend), and 3. vest vs. non-vest days compared to baseline variation (difference of differences). Kruskal Wallis tests were used to compare vest vs. non-vest days across demographic strata (age, sex, race/ethnicity, weight classification, asthma diagnosis, season of recruitment (NYC heating season, October-April, vs. non-heating season)) and questionnaire responses. Age was categorized into tertiles based on the total sample enrolled (n = 163). All analyses were performed using SAS 9.4. Consent and assent were obtained from all participants and the study was conducted in accordance with Columbia University Institutional Review Board guidelines.

3. Results

Demographic characteristics for the 142 children are shown in Table 1. When asked if activity while wearing the vest mimicked normal activity, 71% (n = 101) reported very much or exactly, 17% (n = 24) more or less and 12% (n = 17) very little or not at all. Thirty-eight percent (n = 53) reported they removed the vest other than while sleeping or bathing. Of the 53 children that removed the vest 46% (n = 24) removed it for sports practice or gym class, 4% (n = 2) because it was uncomfortable, 7% (n = 4) because it was too hot and 43% (n = 23) for "other" reasons. Thirty-seven percent of children (n = 19) reported they removed it for > 60 min. Children that removed the vest were older (mean 12.7 ± 0.9 years) compared to children that did not remove the vest (mean 12.3 ± 1.3 years) (P = 0.03).

On average, children were less active on vest days compared to non-vest days (mean difference = 23.1 ± 169 min, P < 0.01). At baseline while not wearing the vest, children were less active on weekends compared to weekdays (mean difference = −26.7 ± 131 min, P = 0.01). There was no difference in vest vs. non-vest day activity compared to baseline variation (P = 0.84). Children that were overall most active had greater differences in vest vs. non-vest day activity compared to children that were less active (Fig. 1).

To examine characteristics associated with the differences in activity between vest and non-vest days, we stratified analysis by demographic characteristics. The differences for younger children (< 12.2 years) were larger (i.e. less active on vest days) in comparison to the differences for older children (P = 0.03, Fig. 2). Similarly, Dominican children were less active on vest days compared to African American children (P = 0.03, Fig. 2). There were no differences across strata for

Table 1
Demographic characteristics for the children included vs excluded in this analysis.

	Included (N = 142)	Not Included[e] (N = 21)	P-value
Age in years, median (range)	12.4 (9.2 – 14.3)	13.2 (12.0 – 14.0)	**< 0.01**
Females, n (%)	73 (51%)	11 (52%)	0.93
Race/ethnicity, n (%)			0.15
African American	51 (36%)	11 (52%)	
Dominican	91 (64%)	10 (48%)	
Weight category, n (%)			0.68
Overweight[a]	39 (27%)	5 (24%)	
Obese[b]	36 (25%)	4 (19%)	
Heating season[c], n (%)	74 (52%)	12 (57%)	0.67
Asthma[d], n (%)	80 (56%)	12 (57%)	0.94

[a] Median and range are included for age.
[b] Overweight defined as BMI ≥ 85th percentile and < 95th percentile for age and sex. Obese defined as BMI greater than the 95th percentile for age and sex.
[c] New York City cold weather season, October–April.
[d] Asthma diagnosis determined by a physician at age 5–12 based on standardized criteria (Donohue et al., 2013).
[e] Due to incomplete accelerometry data.

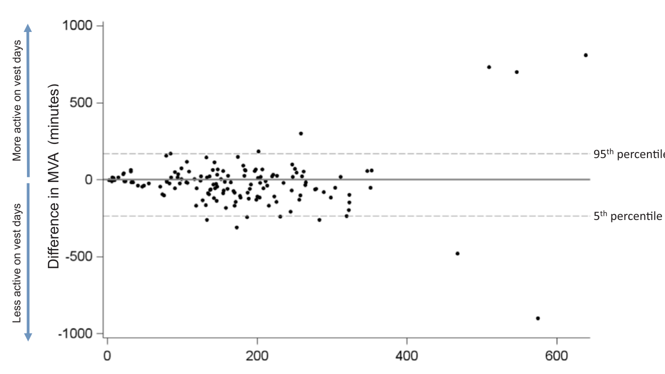

Fig. 1. Bland-Altman plot of average duration of moderate and vigorous activity (MVA) in minutes with and without exposure monitor (vest day and non-vest day) on the x-axis, compared to the difference in MVA time on the y-axis. Children that were most active (highest average MVA time) also had greatest difference in activity on vest versus non-vest days.