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Comparison of allergens collected from furnace filters and vacuum floor dust

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The ideal determinant of allergen exposure would be knowing the specific types and amounts of allergen material deposited in the airways during any period.[1] Because this is impractical, proxies for exposure determination have been used. In homes with forced-air heating ventilation and air conditioning, all air is passed through the system approximately once every hour.[2] The filter in that system should collect a representative sample of airborne allergens. We previously reported that dust from high-efficiency furnace filters (FFs) contains substantial amounts of aeroallergen.[3] In the present report, we describe the relation of FF allergens to allergen levels obtained from floor dust. We hypothesized that measuring allergens in FFs would provide a different assessment of exposure than floor or bedroom dust collection.

FQT12 1-inch disposable FFs were provided by Allergy Zone (Louisville, Kentucky). Antibodies and immunoassay standards were obtained from Indoor Biotechnologies (Chantilly, Virginia) and Greer Laboratories (Lenoir, North Carolina). Assays followed protocols described previously.[3,4] Human subject aspects were approved by the institutional review board of the Children's Mercy Hospital (Kansas City, Missouri). The collection of dust from FFs, HEPA vacuums (HVs), and children's bedroom floors (CRs) has been described previously.[3,5] Briefly, dust was removed from the HV or vacuumed from the CR or the FF using a HEPA unit with an x-cell-100 filter (Midwest Filtration, Cincinnati, Ohio). Levels of Der f 1 and Der p 1 are presented as the sum of dust mite allergens. Results are displayed as nanograms per gram of dust. Descriptive and comparative statistics were generated using SPSS software (IBM Corporation. Armonk, New York). Correlation coefficients were by the Spearman rank correlation equation performed in SPSS.

Demographics for homes in this study have been previously reported.[3,5] All had forced-air heating ventilation and air conditioning systems. For this dataset, 54 homes were included in the FF data; 47 of those homes also had determination of allergen levels in dust taken from the HV, and 35 homes had allergen data from all 3 types of dust collected. Reasons for missing data points varied from insufficient quantity of dust collected to hurried appointments because of occupant requirements.

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Statistical parameters are listed in Table 1. Few determinations were below the detection limit. Fel d 1 levels varied from 7,407 ng/g in FF dust to 635 ng/g in CR dust. Dust mite allergen was greatest in CR dust at 937 ng/g and lowest in FF dust at 240 ng/g. All fungal antigens were higher in FF dust, with *Cladosporium* species (42,342 ng/g) and *Aspergillus* species (34,011 ng/g) more than double the amount measured in HV and CR dust. Fungal allergen levels were detected less frequently in CR dust, with detection of *Alternaria* species in only 45% of homes.

Correlations for the 9 measured species in FF, HV, and CR dust ranged from fair (eg, 0.39 and 0.62 between *Aspergillus* allergen in the FF dust and the 2 reservoir collections) to poor (eg, 0.06 and 0.08 between roach allergen levels in the FF dust and reservoir collection). The most positive and significant correlations between FF and CR dust collections were for *Aspergillus*, cat, dog, and mouse allergens (typically significant at the .01 level).

We found that allergens in FF dust were a function of those present in settled dust for important allergen sources. Nonetheless, settled dust and dust from FF each provide unique information concerning exposure. Our results confirm previous observations concerning the nature of aeroallergens.[6] Dust mite and cockroach allergens, previously reported to be associated with large particles,[6,7] did not correlate well between FF dust and floor dust. In contrast, dog, cat, mouse, and *Aspergillus* allergens, previously reported to be associated with small particles,[8,9] were much better correlated between FF dust and floor dust. Dust mite allergen concentration in FF dust was less than half the value of that allergen in HV dust or CR dust. The observation that dust mite allergen quickly precipitates from the air has been previously documented.[9]

Spearman correlation analysis (Table 1) indicated good correlation between FF dust allergen levels and the 2 settled dust collections for the same house. Correlations were especially good for *Aspergillus* species, Fel d 1, Can f 1, and Mus m 1. Unexpectedly, correlations were not high for 3 of the 4 fungal genera. The 4 allergenic materials with significant positive correlations are believed to be unique to indoor air and would be expected to correlate with settled dust collections even if they were present in the settled dust at lower levels than in the FF dust. The relations of the 2 settled dust collections has been reported previously.[5]

The study has limitations especially in generalizability to other types of housing. Houses were typical to the Midwestern United States. Housing in other areas of the United States might not have the same types of heating and cooling systems. Houses were measured during heating and cooling seasons and we did not have the ability to control how often the heating ventilation and air conditioning fan was operated. All measurements were normalized to gram of dust, not cubic meter of air. Also, different vacuum systems yield different collections.[10]

We found that aeroallergen components filtered from air in Midwestern homes correlate with, but are not identical to, aeroallergen components found in HV dust from those homes. Specific allergens expected to remain airborne for long periods tended to occur at a higher concentration in FF dust. Conversely, those aeroallergens not expected to remain airborne

tended to occur at a lower concentration. The measurement of aeroallergens from FFs represents another avenue for evaluating the overall aeroallergen exposure of allergic individuals. The variability in results based on measurement technique suggests that allergen measurement can be of value in research settings and potentially in selected circumstances where antigen detection is prospectively defined to have potentially important management implications. Caution needs to be exercised when recommending widespread home allergen measurement, including the use of potentially costly health care resources for allergen quantitation, until the clinical value of the results is demonstrated.

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Table 1

Means, SDs, Medians, and Percentages of Homes Where the Allergen Was Detected Above the Lower Level of Detection and Correlations for Allergens in Furnace Filter Dust, Home Vacuum Dust, and Child's Bedroom Floor Dust

	Average	SD	Median	Det %	Corr w/FF	Corr w/HV	Corr w/CR
Allergen in furnace filter dust (ng/g)							
Alternaria sp	8,275	4,945	8,356	91	1.00	0.06	0.22
Aspergillus sp	34,011	34,349	12,545	93	1.00	0.39[b]	0.62[b]
Cat (Fel d 1)	7,407	18,918	843	100	1.00	0.37[a]	0.28
Cladosporium sp	42,342	25,960	35,504	98	1.00	0.10	0.01
Dog (Can f 1)	622	798	180	96	1.00	0.44[b]	0.69[b]
Dust mite (Der f 1 + Der p 1)	240	751	63	100	1.00	0.10	0.38[a]
Penicillium sp	12,248	9,233	10,148	94	1.00	0.10	−0.04
Roach (Bla g 2)	690	2,734	99	96	1.00	0.08	0.06
Mouse (Mus m 1)	343	457	179	98	1.00	0.62[b]	0.55[b]
Allergen in home HEPA vacuum dust (ng/g)							
Alternaria sp	5,469	6,296	3,840	72	0.06	1.00	0.19
Aspergillus sp	16,527	32,871	4,420	72	0.39[b]	1.00	0.43[b]
Cat (Fel d 1)	784	2,553	70	91	0.37[a]	1.00	0.54[b]
Cladosporium sp	15,546	17,911	10,930	81	0.10	1.00	0.50[b]
Dog (Can f 1)	1,478	3,024	310	98	0.44[b]	1.00	0.42[a]
Dust mite (Der f 1 + Der p 1)	625	862	210	100	0.10	1.00	0.41[a]
Penicillium sp	10,476	17,111	6,480	83	0.10	1.00	0.59[b]
Roach (Bla g 2)	623	2,213	80	94	0.08	1.00	0.52[b]
Mouse (Mus m 1)	387	580	140	100	0.62[b]	1.00	0.62[b]
Allergen in child's bedroom floor dust (ng/g)							
Alternaria sp	2,563	3,468	100	45	0.22	0.19	1.00
Aspergillus sp	7,927	18,769	1,425	61	0.62[b]	0.43[b]	1.00
Cat (Fel d 1)	635	1,707	120	95	0.28	0.54[b]	1.00
Cladosporium sp	7,668	13,565	3,585	74	0.01	0.50[b]	1.00

	Average	SD	Median	Det %	Corr w/FF	Corr w/HV	Corr w/CR
Dog (Can f 1)	1,348	3,097	300	100	0.69[b]	0.42[a]	1.00
Dust mite (Der f 1 + Der p 1)	937	1,629	305	100	0.38[a]	0.41[a]	1.00
Penicillium sp	5,074	8,557	1,790	68	−0.04	0.59[b]	1.00
Roach (Bla g 2)	305	597	110	89	0.06	0.52[b]	1.00
Mouse (Mus m 1)	361	585	130	95	0.55[b]	0.62[b]	1.00

Abbreviations: Corr w/CR, correlation for allergens in child's bedroom floor dust; Corr w/FF, correlation for allergens in furnace filter dust; Corr w/HV, correlation for allergens in home vacuum dust; Det %, percentage of homes where the allergen was detected above the lower level of detection.

[a]Correlation is significant at the 0.05 level (2-tailed).

[b]Correlation is significant at the 0.01 level (2-tailed).