

Original articles

Personal pollen exposure compared to stationary measurements

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SUMMARY

The aim of this study was to examine to what extent stationary outdoor pollen measurements are representative for estimating personal exposure to pollen. Ten subjects were studied during a total of 36 days in spring and summer. Pollen was sampled using personal SKC total dust samplers and stationary Burkard pollen traps. The personal activity pattern was recorded quarter-hourly as well as the time spent outdoors. As a reference, SKC and Burkard samplers were run stationary and in parallel. Stationary comparison of the samplers showed good correlation ($r = 0.981$, $p < 0.001$). However, the SKC sampler collected systematically about four times less pollen than the Burkard sampler. Taking into account the systematic difference between the sampling devices, the personal exposure data were about 30% of the stationary pollen concentrations with significant correlation (log-transformed data, $r = 0.719$, $p < 0.0001$). Considering the average time the subjects spent outdoors (14% of sampling time), the indoor-outdoor ratio for pollen was 0.2. In conclusion, pollen reports are reliable for estimating personal exposure over a limited time period although personal pollen exposure is much lower

Key words: Pollen · Personal exposure · Time-activity pattern · Burkard sampler · SKC dust sampler

INTRODUCTION

Routinely published pollen counts usually originate from stationary outdoor measurement sites (1). They are used mainly as preventive measures for people with allergy, and for the allergist to determine the relevant allergens for testing, also with regard to specific immunotherapy. However, people spend a large proportion of

their time indoors. In Europe, for example, people in urban areas stay outdoors for only 1 h per day (2). It is unclear to what extent stationary outdoor measurements are representative for estimating personal exposure to pollen. In air pollution studies, the relationship between personal, outdoor and indoor levels have been assessed [e.g., NO_2 and particles (2-5)]. In longitudinal analysis (i.e., when following subjects over a certain time), the correlation between personal and stationary pollutant levels was better than in cross-sectional analysis (i.e., when comparing different subjects at the same time). For pollen, however, only few studies have been conducted. Studies on the amount of pollen infiltrating school buildings and dwellings revealed indoor/outdoor ratios for pollen concentrations between 0.1 (6, 7) and 0.3 (8), suggesting that the personal exposure to pollen is substantially lower than the numbers published in pollen bulletins. One study (9) determined the personal exposure to pollen. However, only a semiquantitative method was used which mainly provided information on the kind of pollen species, but gave only limited information on the level of exposure.

In this study we use a quantitative technique to measure personal pollen exposure and compare it to stationary outdoor measurements.

MATERIALS AND METHODS

Ten subjects, five men and five women, were studied over a 36-day period in the summer of 1998 during their normal daily activities. Subjects were aged between 21 and 40 years (average age 26 years); nine of them had a higher education; eight studied at one of the universities in Zurich. They all underwent skin

prick testing with aeroallergens (Soluprick, ALK, Hørsholm, Denmark). The subjects carried the personal sampler for a total of 3-5 nonconsecutive days, i.e., each day the sampler was carried by a different person. They recorded their quarter-hourly activity pattern, namely their whereabouts, means of transportation, strength of activity, kind of indoor ventilation, and time spent outdoors.

For personal exposure assessment, pollen was sampled using total dust sampling heads (Cat. No. 225, SKC Inc., USA) attached to the collar of the subjects. The sampling heads were connected to a battery powered pump (Cat. No. 224-PCXR8, SKC, USA) providing a constant flow of 4 l/min and were mounted with cellulose ester filters (37 mm, SKC, USA) on a support pad. The pump was set inside a sound-insulated box and carried by the subject in a small backpack. The measurement was started in the morning before 8:00 a.m., and was usually run for 12 h, according to the capacity limit of the batteries.

After sampling, filters from the SKC sampler were placed on a glass slide, guttered with acetone to turn them into a transparent jelly, and covered with a thin glass slide. Pollen were counted using light microscopy (400 x magnification, Zeiss, Germany).

Stationary pollen counts were obtained from the Swiss National Weather Service (SMI-Swiss Meteo). Sampling was carried out with a Burkard pollen sampler placed on top of the SMI headquarters in Zurich (1). This device is attached to a turning table with a wind blade so that the opening of the sampler always faces in the direction of the wind. Pollen was counted using standard techniques resulting in 24-hourly means (1). For 8 days, SKC and Burkard samplers were run in parallel on top of the SMI building for direct comparison. To do this, two SKC sampling heads were mounted next to the Burkard sampler on top of the SMI building, with their openings facing horizontally in opposite directions. To allow for 24-h sampling the SKC sampling heads were connected to a net-powered pump (Thomas, USA) with critical orifices (Proeco, Czech Republic) providing a constant flow of 4 l/min.

Statistical calculations were made using SYSTAT 8.0 for Windows. Wilcoxon signed rank test was used for group comparison. To account for the skewed distribution and some zero values of stationary and person-

al pollen results over the 36 observation days, pollen data were shifted by unit concentration and log-transformed for calculating correlations.

RESULTS

Description of subjects and activity pattern

The subjects lived and worked within 5 km of the SMI-Swiss Meteo measuring site. Of the 10 subjects, six suffered from hay fever caused by grass and birch pollen, two from seasonal asthma due to grass pollen, and two were asymptomatic, but one showed positive skin prick reactivity to birch.

Subjects spent an average of 97 min (SD 79 min) outdoors, corresponding to 14% of the sampling time (average 693 min). Of the time spent indoors, 32% was at home, 47% at work and the rest was spent elsewhere. Indoors, windows were kept open 43% of the time, in 30% windows were closed, and 27% of the time was spent in rooms with ventilation systems (mainly lecture halls). For transportation, subjects went by foot (42%), or used the tramway (30%), bicycle (24%) and car (4%). Levels of activity were none (resting) in 61%, 37% moderate and 3% strenuous. No difference was seen in any activity pattern between asymptomatic subjects, hay fever sufferers and asthmatics.

Stationary measurements

During the summer of 1999, on 8 nonconsecutive days, stationary pollen collections were made using the SKC samplers placed parallel to the Burkard trap on top of the SMI-Swiss Meteo building in Zurich. Nettle and grass pollen formed the major part of pollen during the sampling period. Table 1 shows the concentrations of the counted pollen. For all pollen species, pollen counts obtained from the Burkard sampler were higher than those from the SKC heads, with average values of 113.5 pollen/m³ (SEM 16.1 pollen/m³) and 27.6 pollen/m³ (SEM 3.3 pollen/m³), respectively. However, correlation between the devices was good ($r = 0.981$, $p < 0.001$, Fig. 1). The slope of 0.24 (± 0.04) indicates that the SKC sampler collected systematically about four times less pollen than the Burkard sampler. This factor was

Table 1

Mean pollen concentrations (pollen/m³) for 8 days of stationary measurements with the Burkard sampler and two SKC dust heads run in parallel

Sampler	<i>Urtica</i> (nettle)	<i>Graminae</i> (grass)	<i>Tilia</i> (lime)	<i>Pinacea</i> (pine)	Unidentified species	Total pollen
Burkard	56.5	37.3	1.8	2.3	15.6	113.5
SKC A	11.7	5.0	0.2	0.3	12.1	29.3
SKC B	10.2	5.5	0.1	0.5	9.5	25.8

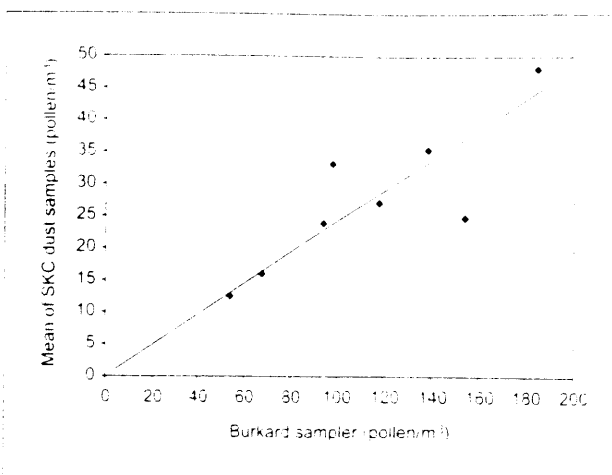


Fig. 1. Comparison of total stationary pollen counts of the two sampler types run in parallel on top of the SMI building in Zurich. The correlation is highly significant ($r = 0.981$, $p < 0.0001$), the slope is $0.24 (\pm 0.04)$.

later used for correction of the data obtained by the Burkard sampler. A comparison of the two SKC samplers run in parallel showed a good correlation ($r = 0.973$, $p < 0.0001$). There were no significant differences between the two SKC sampling heads used.

Personal measurements

Personal measurements were made from April 20 to July 17, 1998. The largest amounts of pollen sampled during this time period were for birch and ash pollen. They were abundant in April and early May. Table 2 shows the mean and the maximal pollen concentrations found during all sampling days. Total personal pollen counts (mean 8.6 pollen/m^3 , range $0\text{--}153 \text{ pollen/m}^3$) were significantly lower than the stationary outdoor concentrations (mean 146.1 pollen/m^3 , range $6\text{--}1132 \text{ pollen/m}^3$) obtained with Burkard samplers dur-

Table 2

Mean and maximum daily individual pollen concentrations during a 36-day period determined using personal SKC dust heads.

Pollen/ m^3	Mean	Maximum
<i>Alnus</i>	0.1	0.8
<i>Artemisia</i>	0.1	1.0
<i>Betula</i>	4.6	98.3
<i>Fraxinus</i>	2.2	54.9
<i>Plantago</i>	0.1	1.2
<i>Platanus</i>	0.2	2.3
<i>Poaceae</i>	0.5	3.1
<i>Quercus</i>	0.7	5.6
<i>Rumex</i>	0.1	0.9
<i>Secale</i>	0.1	0.8
Others	8.4	65.7
Total	8.6	153.5

ing the same days (two-sided Wilcoxon, $p < 0.001$). Similar findings were obtained at the level of the pollen species determined. Figure 2 shows the personal pollen exposure versus the stationary measurements plotted on logarithmic scales. They showed a strongly significant correlation (log-transformed data, $r = 0.719$, $p < 0.0001$) but showed large scattering. Considering the systematic difference between the sampling devices, stationary numbers were multiplied by a factor of 0.24. Calculation of a linear correlation between personal numbers and corrected stationary numbers resulted in a slope of $0.31 (\pm 0.1)$, indicating that the average personal exposure was 31% of the stationary outdoor concentration.

DISCUSSION

Following 10 different subjects in random order throughout spring and summer showed that personal exposure to pollen correlates well with stationary measurements used to report pollen counts. This suggests that stationary measurements are representative of personal pollen exposure. The correlation with the stationary measurements was highly significant but scattered (Fig. 2), which reflects the differences in personal behavior. Since there is a wide range of variation in pollen concentrations, the correlation remains good. These results do not agree with the only study published so far on the comparison of personal and stationary exposure measurements (9). In that study only a weak correlation was found between personal and stationary samplers. The personal sampler used was a plastic case with a round opening and a Vaseline-smeared slide behind it. This allowed probably only a semiquantitative determination of pollen concentrations. Our study on the other hand used established techniques with constant air flow through a filter.

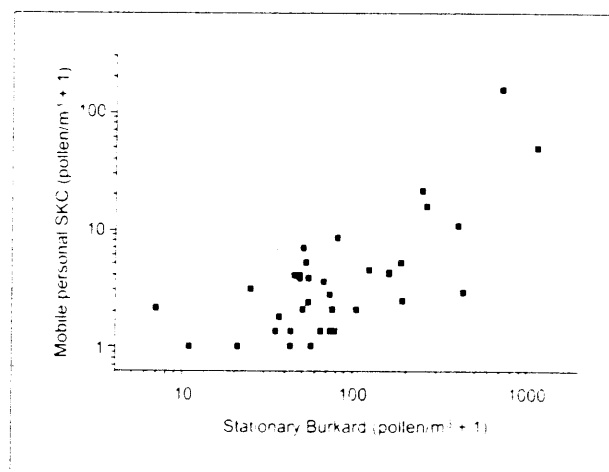


Fig. 2. Relation between stationary and personal sampler. Concentrations show a strongly significant correlation (log transformed data, $r = 0.719$, $p < 0.0001$).

When all the samplers were run in parallel on top of the SMI building about four times less pollen was found in the SKC samplers compared to the concentrations obtained from the Burkard sampler. Because of its design, the Burkard sampler always follows the direction of the wind. It was suggested that this may lead to an overestimation of particle concentrations even at moderate wind speed (10, 11). One study (7) found a difference of a factor of 10 between Burkard samplers and Rotorod samplers. The latter are known to be less influenced by the effects of wind than Burkard traps, which is also an indication of the likelihood of overestimating pollen counts with Burkard traps. To account for the systematic difference between the Burkard and the SKC sampler, the values obtained from the Burkard trap were corrected using a factor of 0.24 in order to compare them with the personal exposures measured with the SKC samplers.

The values found with the personal sampling were on the average 31% of those corresponding to the corrected stationary outdoor levels. This difference would be smaller than expected if exposure to pollen occurred only outdoors, since on the average only a total of 14% of the time was spent outdoors. From this 14% and the corrected data an indoor/outdoor ratio of 0.20 was calculated. This agrees well with previous studies (6-8) using Rotorod pollen samplers.

In conclusion, stationary samplers are sufficient for estimating personal pollen exposure over a certain period of time, e.g., in a day-to-day health effects analysis. Our study suggests that the regularly published pollen data in the Zurich area might be overestimated and that indoor pollen levels are about 20% of the outdoor levels.

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RESUMEN

El propósito de este estudio fue evaluar que medida de concentraciones de polen exterior es representativa para la exposición personal al polen. Diez sujetos fueron estudiados durante un total de 36 días en primavera y verano. El polen se recogió mediante medidores personales de polvo SKC y estaciones recolectoras de polenes Burkard. La actividad personal se registró cada cuarto de hora así como el tiempo pasado en el exterior. La comparación estacional entre los recolectores mostró una buena correlación ($r = 0.981$, $p < 0.001$). Sin embargo, la recolección de muestras mediante SKC fue aproximadamente cuatro veces menor que en los recolec-

tores Burkard. Considerando las diferencias sistémicas entre los dos métodos de recolección, los datos de exposición personal fueron de un 30% de la concentración estacional de polen y se correlacionaron significativamente (datos logarítmicamente transformados ($r = 0.719$, $p < 0.0001$)). Considerando la media de tiempo que los sujetos pasaban fuera (14% del tiempo de recogida), la razón exterior-interior fue para el polen de 0.2. En conclusión, la recogida de polen es útil para la estimación personal de la exposición durante un tiempo limitado, aunque la exposición al polen es más baja.

Palabras clave: Polen - Exposición personal - Patrón de tiempo-actividad - Recolector Burkard - Recolector de polvo SKC

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