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# Decreasing irritation symptoms by replacing partially coated acoustic glass wool boards with fully coated boards

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**Objectives** The aim of this study was to assess the effects of eliminating the potential main fiber source (ceiling boards) in an office environment on exposure to synthetic vitreous fibers (SVF) and the prevalence of different symptoms among office workers

**Methods** In the intervention, partially coated acoustic ceiling boards were replaced with totally coated boards on one floor of an office building. The intervention group consisted of 32 employees working on the floor with the replaced ceiling boards. The reference group (N=34) comprised office workers on another floor, where no such changes had been made. Both groups filled out baseline and follow-up questionnaires and underwent nasal lavage. SVF were collected from samples of settled dust on office surfaces and analyzed using stereomicroscopy. Standardized questionnaires and nasal lavage were analyzed before and after the intervention. Follow-up with a questionnaire was also carried out 3 years later.

**Results** Reported eye, nasal, and facial skin symptoms decreased in the intervention group, but not in the reference group, during the 3 years of follow-up.

**Conclusions** The findings of this intervention support the suspicion that SVF originating from acoustic materials made of partially covered glass fibers may cause the sensation of dry air and mucosal, respiratory, and skin symptoms among office workers. If SVF exist in the dust settled on surfaces in an office, the elimination of the SVF source should be an effective way of decreasing irritation symptoms. The findings also show that intense cleaning is an effective way to reduce symptoms.

**Key terms** acoustic ceiling board; manmade mineral fibers; synthetic vitreous fibers.

Exposure to synthetic vitreous fibers (SVF), or manmade mineral fibers (MMMF), is possibly associated with the irritation of mucous membranes among office workers. Research on this topic has thus far been scarce (1, 2). Diverse insulation and adsorption materials in ventilation ducts have been considered the main source of released fibers (3). In addition, in one case study, fibers released from ceiling boards containing MMMF were associated with an increased prevalence of irritative skin, eye, and respiratory symptoms (2). The aim of our study was to assess the effects eliminating the potential main fiber source (ceiling boards) in an office environment on the exposure to SVF and the prevalence of different symptoms among office workers.

## *Study population and methods*

Indoor-air problems were suspected of being associated with increased symptoms in one office building in Finland (a broadcasting company). In a technical building survey carried out by experts of the Finnish Institute of Occupational Health, exposure to SVF was

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detected, and other reasons for indoor-air complaints were excluded. Partially uncovered acoustic ceiling boards found during the survey were replaced with fully covered boards on one floor of the office building. The intervention group consisted of 32 employees. The reference group comprised the office workers (N=34) situated on another floor where no changes were made in the building materials. Intensified cleaning without emptying the room was carried out similarly on both floors after the intervention. The intervention did not include any active changes in the ventilation or the other physical parameters during the follow-up. SVF were collected from samples of settled dust on office surfaces and analyzed with electron microscopy in order to exclude other potential sources in the ventilation system. The origin of the fibers in the settled dust was shown to be ceiling materials.

The influence of the replacement and cleaning was followed with SVF sampling. Samples of settled dust were collected from the top of a visual display unit (VDU) with sticky gelatinous foil (BM-Dustlifters®, BVDA International BV, Netherlands, area 14 cm$^2$) during a 1-week period in nine rooms on the intervention floor. The VDU was chosen for the sampling surface in order to standardize the settlement time and place. The number of SVF (length ≥20 µm) was calculated with the use of stereomicroscopy (Leica MZ12, Germany, magnification 80–100 x).

Nasal lavage samples were obtained before and after the intervention from 13 volunteers in the intervention group and from 14 volunteers in the reference group according to the model of Paananen et al (4). The ethics committee of the Helsinki and Uusimaa hospital district gave permission for the nasal lavage (Dnro 634/E2/02). After sufficient patient information had been distributed, informed consent was obtained from those who participated in the lavage analysis. Both nostrils were lavaged with 4.5 ml of physiological salt solution with a syringe and soft catheter. The fluid was refluxed three times. The analysis was performed using optical microscopy according to the modified method of Linnainmaa et al (5).

A specimen sufficient for analysis was collected from every participant. The first specimen of two referents had fiber concentrations that were 15- to 50-fold higher than those in the specimens taken after the intervention. The reason for these high concentrations was not found, even when the participants were interviewed about potential sources of fibers (own building work, etc). Contamination of the specimens was suspected. Therefore the values of these two specimens were not included in the final results.

The results of the nasal lavage were classified into the following dummy variables: specimens with fibers and specimens without any fibers. A comparison of these categories was made separately in both study groups before and after the intervention (McNemar test). In addition, comparisons of changes in the fiber counts (>20 µm fibers/ml) between the study groups were made with the Mann-Whitney U-test and Student t-test. Due to a skewed distribution, logarithmic changes in the fiber counts were made before the t-test.

All of the questionnaires administered during the follow-up were carried out using a standardized questionnaire (6, 7) administered three times in both groups (before the intervention, immediately after the intervention, and finally 3 years after the intervention). All of the questionnaires were administered in the same season of the year (October–November). The response rate varied in the intervention group from 75% to 91%, and for the reference group the corresponding values were 56% to 76%, respectively.

We studied the differences in the occurrence of symptoms using cross-tabulations. For the questions on complaints concerning work environment factors and the prevalence of symptoms, the proportions of those with complaints at least weekly in each time period were calculated separately for the two study groups. The data were analyzed using SPSS 14.0 statistical software (SPSS Inc, Chicago, IL, USA). Mann-Whitney U-tests were used to test whether the two samples came from the same distribution. First, the difference between the 2002 and 2003 questionnaires was determined, and then the results of the 2002 and 2005 questionnaires were compared. The level for statistical significance was set at P=0.05.

## Results

### Exposure

SVF samples were taken in six phases on top of a VDU in nine rooms (figure 1). Only after the partially

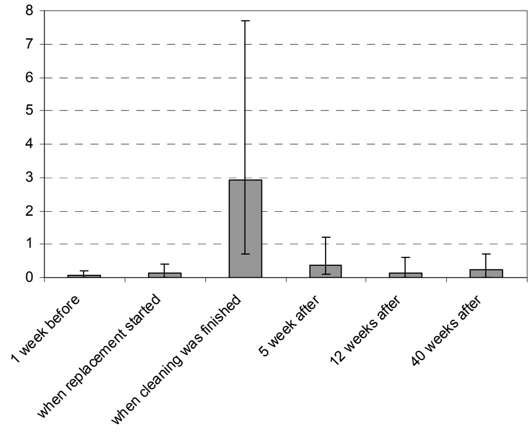


**Figure 1.** Mean concentrations of synthetic vitreous fibers (length ≥20 µm) in settled dust. The vertical lines represent the range of the concentrations.

uncovered ceiling boards were replaced was there an increase in the number of fibers, and this number decreased quickly due to intensified weekly cleaning. However, the fiber levels stayed slightly elevated after the intervention for the entire follow-up time.

### *Nasal lavage*

The nasal lavage samples were analyzed before and after the intervention in both groups (figure 2). In the nasal lavage, the number of fibers tended to decrease more in the intervention group than in the reference group (P=0.072). When "clean" results (0.0 fibers/ml) and "nonclean" results in the nasal lavage were considered in a paired analysis, there was a significant increase in "clean" results only in the intervention group (P=0.03; McNemar test).

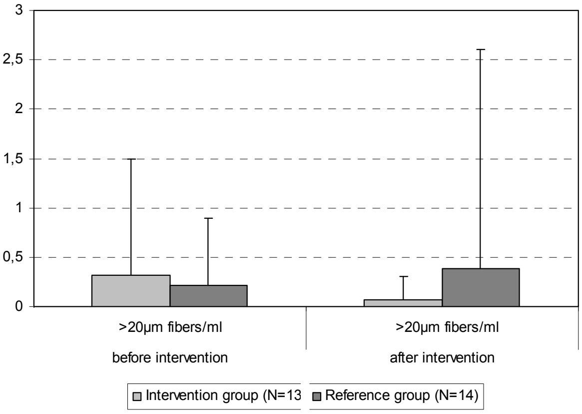


**Figure 2.** Mean concentrations of synthetic vitreous fibers in the nasal lavage samples taken before and after the intervention. The vertical lines show the range of the concentrations.

**Table 1.** Weekly complaints concerning work environment factors according to a standardized questionnaire administered in 2002, 2003, and 2005.

| Complaint | Intervention group [a] | | | Reference group [a] | | |
|---|---|---|---|---|---|---|
| | 2002 (N=24) | 2003 (N=29) | 2005 (N=24) | 2002 (N=26) | 2003 (N=19) | 2005 (N=25) |
| Draft | 0.0 | 0.0 | 4.2 | 26.9 | 15.8 | 36.0 |
| Room temperature too high | 0.0 | 3.4 | 4.2 | 4.3 | 0.0 | 4.0 |
| Varying room temperature | 0.0 | 0.0 | 0.0 | 8.3 | 5.3 | 12.0 |
| Room temperature too low | 4.3 | 7.1 | 4.2 | 20.0 | 16.7 | 28.0 |
| Stuffy ("bad") air | 41.7 | 28.6 | 16.7 | 24.0 | 10.5 | 4.0 [b] |
| Dry air | 39.1 | 13.8 [b] | 12.5 [b] | 28.0 | 10.5 | 28.0 |
| Unpleasant odor | 17.4 | 10.3 | 0.0 [b] | 20.8 | 16.7 | 4.0 |
| Static electricity, often causing shocks | 0.0 | 3.4 | 4.2 | 7.7 | 15.8 | 8.0 |
| Passive smoking | 8.3 | 17.2 | 0.0 | 11.5 | 15.8 | 4.0 |
| Noise | 0.0 | 3.4 | 4.2 | 0.0 | 5.6 | 8.0 |
| Light that is dim or causes glare or reflection | 0.0 | 3.4 | 4,.2 | 0.0 | 5.3 | 12.0 |
| Dust and dirt | 33.3 | 0.0 [c] | 8.3 [b] | 15.4 | 5.3 | 16.0 |

[a] Percentage of respondents.
[b] P<0.05.
[c] P<0.01.

### *Questionnaire*

Before the intervention, the most common complaints were stuffy ("bad") air, dry air, unpleasant odor, and dust and dirt, all of which decreased in the first-year follow-up according to the questionnaire responses of both groups. After 3 years of follow-up, the decrease in the complaints concerning dry air, unpleasant odor, and dust and dirt was significant (P<0.05) only for the intervention group, whereas in the reference group the number of complaints increased (table 1 and figure 3).

Eye, nasal, throat, and facial skin symptoms, as well as fatigue, decreased in the intervention group, but not in the reference group, during the follow-up time (table 2 and figure 4). The reduction was significant (P<0.05) for fatigue and nose and facial skin symptoms. In addition, the prevalence of symptoms related to the indoor work environment decreased significantly.

The only significant negative change in the psychosocial factors in the follow-up concerned the reference group's response as to whether or not the work was interesting and stimulating.

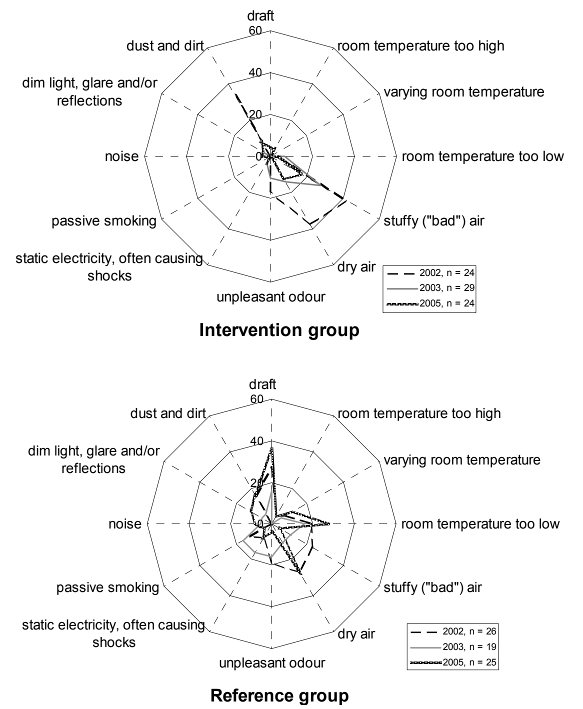


**Figure 3.** Weekly complaints concerning work environment factors according to a standardized questionnaire administered in 2002, 2003, and 2005.

## Discussion

The findings of this pragmatic intervention study supports the suspicion that SVF originating from acoustic materials made of partially covered glass fibers may cause the sensation of dry air, as well as mucosal, respiratory, and skin symptoms, among office workers. In an earlier study, such symptoms showed an increase during the renovation of surfaces containing manmade mineral fibers (3). If SVF exist in the dust settled on surfaces in an office, the elimination of the SVF source seems to be an effective way of decreasing reported irritation symptoms. However, the impact is delayed. Therefore, the follow-up questionnaire survey should not be carried out very soon after the renovation, and it should take place in the same season of the year in which the renovation work was done. This delayed effect has also been found with respect to renovations made to decrease dampness (8).

An experimental study design would be ideal for these kinds of interventions. However, it is practically impossible to carry out randomized controlled trials with blinding in worklife. A pragmatic approach makes "placebo" or "Hawthorne" effects possible because every participant is conscious of the intervention procedures (renovation and consequent necessary intensified cleaning). In our study, however, a long follow-up period showed a notable difference in the number of reported complaints and symptoms between the study groups over a period of 3 years. Because this pragmatic intervention produced limited evidence, randomized (and blinded if possible) or controlled studies are needed to show a causal relationship between exposure to SVF and irritation symptoms.

When long-term changes are reviewed, one must be critical because problems with the indoor environment are multifactorial in origin. Negative changes in the psychosocial work environment, as were observed in the job content of the reference group, can aggravate the symptoms attributed to indoor air (9–11). The members of the reference group perceived their work as being less interesting and stimulating in 2005 than in 2002. This change may have reflected the organizational changes that especially took place with respect to the reference group in 2003. These changes may have been confounding factors and may have increased the symptoms to some extent.

Our findings may also show that intense cleaning is an effective way to reduce symptoms, since, during the first year after the intervention, the symptoms decreased in both groups. In earlier studies, cleaning has had a similar fiber-reducing effect (2, 12). The results of our long follow-up indicate that cleaning seems to work as an aid when problems are detected, but the permanent solution requires the elimination of SVF sources.

**Table 2.** All symptoms occurring weekly according to a standardized questionnaire administered in 2002, 2003, and 2005.

| Symptom | Intervention group [a] | | | Reference group [a] | | |
|---|---|---|---|---|---|---|
| | 2002 (N=24) | 2003 (N=29) | 2005 (N=24) | 2002 (N=26) | 2003 (N=19) | 2005 (N=25) |
| Fatigue | 25.0 | 20.7 | 8.3 | 46.2 | 22.2 | 28.0 |
| Feeling heavy-headed | 20.8 | 13.8 | 4.2 | 26.9 | 11.1 | 24.0 |
| Headache | 8.3 | 3.6 | 4.2 | 11.5 | 5.6 | 20.0 |
| Nausea or dizziness | 8.7 | 0.0 | 4.2 | 16.0 | 0.0 | 0.0 [b] |
| Difficulties concentrating | 4.2 | 3.6 | 4.2 | 0.0 | 0.0 | 8.0 |
| Eye irritation | 52.2 | 10.7 [c] | 20.8 [b] | 30.8 | 11.1 | 32.0 |
| Irritated, stuffy or runny nose | 52.2 | 13.8 [c] | 16.7 [b] | 42.3 | 22.2 | 36.0 |
| Hoarse, dry throat | 39.1 | 10.3 [b] | 8.3 [b] | 23.1 | 11.1 | 28.0 |
| Cough | 8.7 | 6.9 | 8.3 | 7.7 | 5.6 | 16.0 |
| Dry or flushed facial skin | 58.3 | 17.2 [c] | 16.7 [c] | 34.6 | 11.8 | 44.0 |
| Scaling or itching scalp or ears | 30.4 | 7.1 [b] | 8.3 | 23.1 | 22.2 | 32.0 |
| Hands dry, itching, red skin | 41.7 | 20.7 | 25.0 | 42.3 | 16.7 | 40.0 |

[a] Percentage of respondents.
[b] P<0.05.
[c] P<0.01.

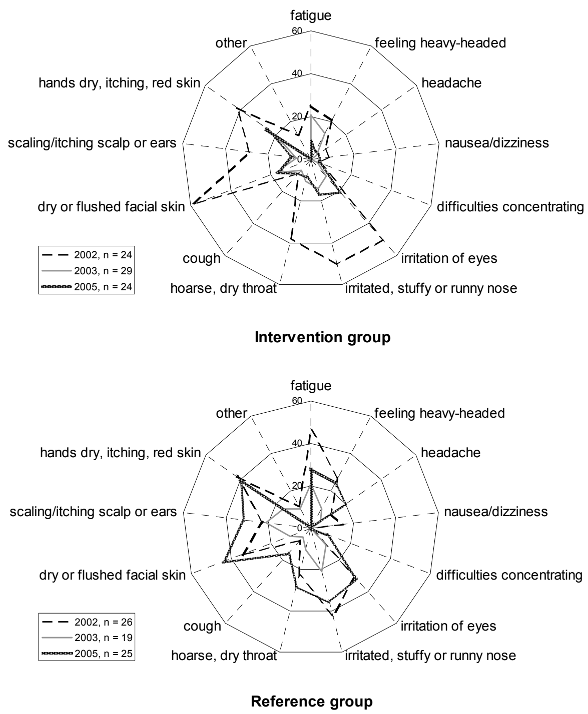


**Figure 4.** All symptoms experienced weekly according to a standardized questionnaire administered in 2002, 2003, and 2005.

SVF sampling using a gelatinous foil would be a simple and economic method for follow-up, but the 1-week period we used was too short for collecting enough fibers for analysis purposes. This result is parallel with findings showing that the number of fibers in settled dust on regularly cleaned surfaces is usually small and 60% of such samples are clean (13). During the intervention the available recommendations for sampling did not define the time period for collecting settled dust. Later Finnish practice has set a period of 2 weeks as the recommended collection time (14). The foil sampling method does not lend itself to the reliable detection at an SVF source. Instead, analysis with electron microscopy is a proper tool because the source can be identified by the element composition of the fiber.

The concentrations of fibers measured with the use of the nasal lavage method were low. In contrast to electron microscopy, optical microscopy does not find the abundant smallest fibers, and the fiber counts remain far lower than reported with the use of electron microscopy (4). In the office environment, the fiber concentrations are one-third to one-fifth of the concentrations measured in the glass wool industry (14). Although our nasal lavage results correlated with the subjectively determined irritation symptoms, the results are inconclusive because of the small number of examined persons. Participation was voluntary, and therefore the number of lavage analyses was restricted. However, the participation did not seem to be associated with the prevalence of symptoms or other background factors. It is likely that the nasal lavage method works best in environments with higher fiber concentrations. The use of nasal lavage in the study of fiber problems in office environments is not recommended as a routine procedure.

The use of acoustic ceiling boards with only the visible side coated are widely used in office environments. Therefore, it can be concluded that these types of acoustic board contain the potential sources that cause irritation symptoms. We recommend that partially uncovered acoustic ceiling boards not be used in the indoor environment and no longer manufactured for that purpose. If nonspecific irritation symptoms are detected in the workplace and no other imminent reason for indoor air complaints of employees is shown, the existence of SVF in settled dust should be checked by surface sampling, and the SVF source should be identified with an electron microscopic analysis. This procedure can help guide the renovation process, and unnecessary costs can be avoided.

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