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The Effect of Indoor Foliage Plants on Health and Discomfort Symptoms among Office Workers

Abstract

Indoor plantings are widely used in building environments though little is known regarding the way office workers respond to indoor foliage plants. The objective of the present study was to assess the effect of foliage plants in the office on health and symptoms of discomfort among office personnel. A cross-over study with randomised period order was conducted; one period with plants in the office and one period without. A questionnaire consisting of 12 questions related to neuropsychological symptoms, mucous membrane symptoms and skin symptoms was distributed among the 51 healthy subjects who participated in the study. It was found that the score sum of symptoms was 23% lower during the period when subjects had plants in their offices compared to the control period. (Mean score sum was 7.1 during the period without plants vs. 5.6 during the period with plants.) Complaints regarding cough and fatigue were reduced by 37 and 30%, respectively, if the offices contained plants. The self-reported level of dry/hoarse throat and dry/itching facial skin each decreased approximately 23% when plants were present. Overall, a significant reduction was obtained in neuropsychological symptoms and mucous membrane symptoms, while skin symptoms seemed to be unaffected by the presence of plants. The results from this study suggest that an improvement in health and a reduction in symptoms of discomfort may be obtained after introduction of foliage plants into the office environment.

Key Words
Indoor plants
Health
Discomfort
Office workers

Introduction

The interior climate in office buildings has changed over the years due to the introduction of new building materials and increased emphasis on energy saving. At the same time, it seems that health and discomfort problems have increased among office workers [1]. Common complaints are cough, irritation of the nose, upper airways, throat, skin and eyes and neurological symptoms such as drowsiness, nausea, dizziness, headache and loss of concentration. As a result the indoor air quality of office buildings has become an important environmental issue [2].

During the 1980s it was reported that plants may reduce the level of air contaminants, such as formaldehyde, benzene, trichloro-ethylene, carbon monoxide and

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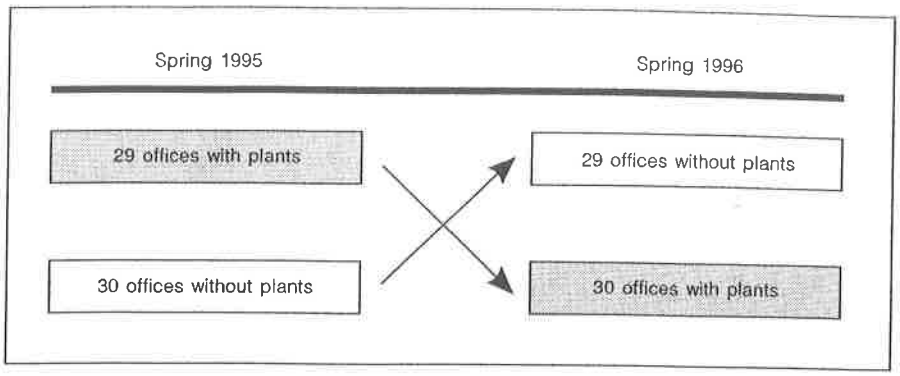

Fig. 1. Flow-chart showing the cross-over design of the study. During the data sampling periods (spring 1995 and spring 1996, see text), questionnaires were collected from the subjects every 2nd week.

nitrogen dioxide [3, 4]. Indoor plantings can produce a 'positive' perception of the indoor environment. Studies have shown that the well-being of people and their psychological and physiological stress levels are appreciably influenced by their surroundings. It appears that vistas dominated by vegetation may give relief from stress [5–8]. It is therefore relevant to investigate to what extent indoor plantings may affect the well-being of people who are working in modern office buildings and who often complain of health and discomfort problems. No studies seem to have been carried out concerning this issue. The objective of the present study was to assess whether foliage plants used for indoor decoration may affect the way office personnel react to health and discomfort symptoms.

Methods

A total of 59 office employees at a Norwegian oil company participated in the study. A previous survey had revealed that these people had in the past experienced symptoms which they considered to be caused by poor indoor air quality. Only people who volunteered and who worked in single office rooms were included in the study. During the experimental period, 8 of the subjects withdrew from the project; 1 person did not want plants any more, and 7 people moved to work in another building. As a result, the statistical analyses were based on the results from 51 people.

The trial was conducted as a randomised 'cross-over' study. The subjects completed a questionnaire every 2nd week about 12 different health symptoms during two spring periods of 3 months in 1995 and 1996. The questionnaire, which was modified after Anderson et al. [9], included questions on the following 12 symptoms: (1) fatigue, (2) feeling heavy-headed, (3) headache, (4) nausea/drowsiness, (5) concentration problems, (6) itching, burning, irritation of the eyes, (7) irritated, stuffy or 'running' nose, (8) hoarse, dry throat, (9) cough, (10) dry or flushed facial skin, (11) scaling/itching scalp or ears, (12) hands with dry, itching, or red skin. Each symptom could be given one of the following scores: 0 (no problems), 1 (minor problems), 2 (moderate problems) or 3 (severe problems). The scores given should reflect problems experienced on the same day the questionnaire was completed.

In February 1995 plants were placed in half of the offices, while the rest remained without plants until February 1996. At this time, the plants were transferred to the former control offices (fig. 1).

The participants worked in single office rooms which were all identical with a floor area of 10 m^2 and a window covering most of the outer wall. Each room was ventilated individually, receiving air from a central ventilation system. The air entering the building was filtered by means of a Camfield 85 filter, which was replaced every 6 months. The relative air humidity was kept at 35–40% during winter. During summer the relative air humidity was seldom lower than 60%. During the period of the study the air temperature was kept between 22 and 24 °C.

The plants used for the study were: four *Aglaonema commutatum*, two *Dracaena deremensis*, four *Epipremnum aureum* and three *Philodendron scandens* on the window bench. In the back corner of the office, close to the entrance, one terracotta container was placed with one 1.75-meter-high *Dracaena fragrans* and four *Epipremnum aureum* (fig. 2). The plants were grown in a medium consisting of a mixture of extruded clay (Leca pearls), peat and compost. The system for the care of the plants was based on self-watering and was in the hands of a professional plant service firm. The plants used have been reported to influence the concentration of air contaminants in sealed chambers [4]. None of the plant species have been reported to give allergic reactions.

In an attempt to reduce the possible effect of increased attention (Hawthorn-effect) which might arise as a result of the office planting, health service personnel from the company visited the participants whose offices had no plants on several occasions during the spring of 1995 to offer them a free nature poster of their own choice to put on the wall. Approximately 1/3 of the subjects approached accepted this offer. Employees from the plant service firm visited the offices with plants every 3rd week. They minimised their contact with the subjects mainly by taking care of the plants outside normal working hours.

Statistical Analyses

Since most of the subjects did not fill in the questionnaire at every sampling date (due to travelling, illness, etc.), a mean score was calculated for each person for every single symptom over the two periods, spring 1995 and spring 1996. The statistical analysis was based on these mean scores, together with the mean sum score (summarised

Fig. 2. Picture showing the foliage plants that were placed on the window-bench in the office (**a**) and in the back-corner of the office (**b**).

for *all* 12 symptoms). A two-sided Wilcoxon signed-rank test was used to decide if a mean difference between the periods with and without plants was statistically significant. The significance level was 5%.

If the effect of a treatment depends heavily on whether the treatment is given in the first or in the second period (carry-over effect), this will destroy the cross-over design. In the present study no carry-over effects were seen in any of the symptom scores.

Results

Neuropsychological Symptoms

Neuropsychological symptoms sum score is the sum of the following symptoms: fatigue, feeling heavy-headed, headache, nausea/dizziness and concentration problems. This sum score was reduced by 23% if the offices contained plants ($p = 0.008$), from a mean score of 2.6 to a mean score of 2.0 (table 1). Results for each single symptom are also shown in table 1. Complaints regarding fatigue were reduced by 30%, from 0.82 to 0.58 ($p < 0.001$). The other four single symptoms in this group were not significantly reduced by the intervention of plants.

Mucous Membrane Symptoms

This group includes the following symptoms: itching, burning or irritation of the eyes; irritated, stuffy or 'running' nose; hoarse, dry throat, and cough. Introducing plants reduced the mean sum score by 24% ($p = 0.005$), from 2.5 during the control period, to 1.9 when plants were present (table 2). During the period with plants complaints regarding dry, hoarse throats were reduced by 25% ($p = 0.022$) and for cough by 37% ($p = 0.020$; table 2).

Skin Symptoms

Three symptoms are included in the mean sum score of skin symptoms: dry or flushed facial skin; scaling or itching scalp or ears, and dry, itching red skin on hands. The presence of plants did not affect this group of symptoms ($p = 0.16$; table 3). However, complaints about dry or flushed facial skin were significantly reduced (23%, $p = 0.044$) when the subjects had plants in their offices (table 3).

Sum of Symptoms

The mean score summarised for all 12 symptoms had a value of 7.1 during the period without plants. A 21% reduction in this figure ($p = 0.002$) was found during the period with plants (table 4).

No negative reports were given during the study period by any of the participants.

Table 1. Effects of plant intervention on complaints regarding mean sum score of neuropsychological symptoms, and on mean scores of the five separate neuropsychological symptoms: fatigue, feeling heavy-headed, headache, dizziness/nausea and problems of concentration (n = 51 subjects)

	Period without plants	Period with plant intervention	Difference
Sum of neuropsychological symptoms			
Mean sum score	2.6	2.0	0.6
SD	2.3	1.7	1.5
min–max	0–10.7	0–7.0	−3–5
p value			0.008
Fatigue			
Mean score	0.82	0.58	0.24
SD	0.62	0.52	0.48
min–max	0.0–2.0	0.0–2.4	−0.9–1.5
p value			<0.001
Feeling heavy-headed			
Mean score	0.71	0.58	0.13
SD	0.61	0.47	0.49
min–max	0–2.3	0–1.8	−1.3–1.5
p value			0.055
Headache			
Mean score	0.33	0.27	0.06
SD	0.52	0.45	0.41
min–max	0–2.3	0–2.0	−1.5–0.8
p value			0.25
Dizziness/nausea			
Mean score	0.27	0.22	0.05
SD	0.48	0.36	0.34
min–max	0–2.3	0–1.3	−0.8–1.7
p value			0.34
Problems concentrating			
Mean score	0.50	0.42	0.08
SD	0.51	0.41	0.42
min–max	0–2.0	0–1.3	−1.0–1.3
p value			0.22

Table 2. Effects of plant intervention on complaints related to the mean sum scores of mucous membrane symptoms and on the mean scores of four separate symptoms related to irritation of eyes, nose, throat and on cough (n = 51 subjects)

	Period without plants	Period with plants	Difference
Sum of mucous membrane symptoms			
Mean sum score	2.5	1.9	0.6
SD	2.0	1.4	1.5
min–max	0–7.2	0–5.6	−2.8–4.3
p value			0.005
Itching, burning or irritation of the eyes			
Mean score	0.70	0.59	0.11
SD	0.62	0.52	0.45
min–max	0–2.6	0–2.3	−1–1.4
p value			0.14
Irritated, stuffy or 'running' nose			
Mean score	0.60	0.43	0.17
SD	0.63	0.45	0.57
min–max	0–2.0	0–1.8	−1–1.5
p value			0.081
Hoarse, dry throat			
Mean score	0.83	0.62	0.21
SD	0.78	0.61	0.62
min–max	0–3.0	0–2.4	−1–2.0
p value			0.022
Cough			
Mean score	0.38	0.24	0.15
SD	0.49	0.32	0.46
min–max	0–1.6	0–1.2	−1–1.2
p value			0.020

Discussion

The present study strongly suggests that foliage plants in the office improve health and reduce discomfort symptoms. Our findings may have a number of explanations of which the three most likely and major ones are: (1) improvement of air quality by the plants, (2) an increase in general well-being due to the perception of foliage plants or (3) the effect of increased attention.

Earlier studies have shown that commonly used species of indoor foliage plants may reduce air contamination. Plants exposed to high levels of chemicals in sealed plexiglass chambers may markedly reduce the concentration of air contaminants [3, 4, 10]. These results do, however, not necessarily apply to the office condition, since the removal rate of pollutants by plants is much slower than that of an optimally functioning ventilation system [11]. On the other hand, a minor change in the content of air contaminants might have a positive influence on the employees' perception of comfort [12] and thereby result in a lower score for the reported health and discomfort symptoms. The symptoms chosen for this study are known to be affected by indoor air quality [2, 9, 13, 14].

The plants might also increase the air humidity by up to 15% [15, 16]. The moisture given off by the plants to the surrounding air is influenced by many factors, e.g. number of plants, temperature, the amount of water supplied, as well as the volume of air in the space enclosing

Table 3. Effects of plant intervention on complaints related to the mean sum score of skin symptoms and on the mean scores of the three separate symptoms: dry or flushed facial skin, scaling or itching scalp or ears and itching, red skin on hands (n = 51 subjects)

	Period without plants	Period with plants	Difference
Sum of skin symptoms			
Mean sum score	2.0	1.7	0.3
SD	1.7	1.4	1.3
min–max	0–6.6	0–4.8	−2.8–4.4
p value			0.16
Dry or flushed facial skin			
Means score	0.88	0.68	0.20
SD	0.78	0.66	0.63
min–max	0–3.0	0–2.5	−1.3–2.0
p value			0.044
Scaling or itching scalp or ears			
Means score	0.56	0.51	0.05
SD	0.70	0.65	0.61
min–max	0–2.6	0–2.5	−1.8–1.8
p value			0.38
Itching, red skin on hands			
Mean score	0.52	0.50	0.02
SD	0.66	0.63	0.49
min–max	0–2.2	0–2.3	−1–1.4
p value			0.76

Table 4. Effects of plant intervention on health and discomfort symptoms

	Period without plants	Period with plants	Difference
Mean score	7.1	5.6	1.5
SD	4.7	3.3	3.1
min–max	0.0–18.6	0.6–13.0	−4.8–11.4
p value			0.002

The score given is the mean score summarised for 12 symptoms (n = 51 subjects).

the plants and the rate of air exchange [15–17]. An increase in humidity and a decrease in carbon dioxide due to improvements in the ventilation system have recently been shown to reduce complaints of 'sick building syndrome', a reduction which has been maintained for 3 years [18]. However, it appears that the air quality and the ventilation capacity in our office settings are better than minimum requirements. In buildings with a modern, well-functioning ventilation system, the increased humidity from the plants would tend to be distributed throughout the building. It is, however, likely that there will be a microclimate around the plants which will produce a somewhat higher level of humidity locally. This might affect the subjects' perception of the air quality, especially since most of the plants were placed close to the subjects. Thus, one explanation of our results may be the effect of plants on the local air quality, especially the humidity.

The reduction in health complaints during the period with plants may also be explained by an improvement in the feeling of well-being. Several studies have shown that the passive experience of being in environments or settings with a view of vegetation tend to have a positive influence on well-being. According to Ulrich and Parsons [8] it seems clear that the benefit of viewing vegetation goes far beyond the aesthetic and includes not only psychological effects, but also measurable physiological effects [5, 6, 19–21]. Relief from stress may be accomplished faster and more completely if the setting is dominated by vegetation than if it is an urban one with little or no vegetation [5, 22]. It has also been reported that the recovery of patients from surgery may be influenced by the view the patient has through the window. Patients who looked out on trees had a shorter post-operative stay and fewer post-surgical complications compared to patients who looked out onto a brick wall [23]. Until now, most studies have been conducted with respect to settings from nature outdoors or urban settings with vegetation. Scientific investigations regarding the effects of indoor plants and flowers on emotional states and stress recovery are lacking. The results of the present study suggest, however, that similar favourable responses may be obtained by indoor plants. Our second explanation that plants produce an increase in general well-being is, therefore, also tenable.

The third explanation of our findings was that they are an effect of increased attention. An attempt to minimise this effect was performed by giving the control group the opportunity to have a nature poster on their office wall. An argument against a strong effect of this sort in this study is that not all variables investigated showed an effect due to plants. In the main only those that a priori were assessed to be related to cleaner and more humid air were affected. Thus, we consider an effect due to the increased attention paid to the subjects to be of minor importance in the present study.

In conclusion, the present study strongly suggests that plants in offices may markedly reduce symptoms of discomfort. It appears that improved air quality and a perceived nicer office environment may be the main explanations for this finding.

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