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Reducing electromagnetic irradiation and fields alleviates experienced health hazards of VDU work

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Abstract

Word Heath Organisation (WHO) outlined in 2005 recommendations, how to treat people suffering from the functional impairment electrohypersensitivity in its document "Electromagnetic fields and public health". Unfortunately the reduction of electromagnetic fields was not considered as a treatment option. The aim of the current study was to shield the computer user from the emitted electromagnetic irradiation and fields and to correlate that to the subjective symptoms reported by electrohypersensitive volunteers. The irradiation of the shielding cabinets was recorded. They housed either separate computer screens or whole laptops. When the volunteers had used the shielding cabinet for 1–7 years, they were able work with their computers whole working day, Those who had used the shielding cabined for 2–3 months were partially symptom free. The person who had used the cabinet only for 1 week reported some alleviation of her nausea. In conclusion: it seems that reducing the electromagnetic irradiation of the computer can lessen the symptoms of electrohypersensitivity and permit working without problems. Further studies are needed to clarify how the symptoms of different organ systems recover and make computer users to work also professionally.

Keywords: Electromagnetic irradiation; Shielding cabinet; Computers; Electrohypersensitivity; Skin reactions

1. Introduction

Symptoms of electromagnetic hypersensitivity were first described in persons working on visual display units (VDUs) (also known as computer monitors or screens) in the early 1980s. The reported symptoms were typically various kinds of skin symptoms such as stinging, burning and itching sensations on the face, upper body and arms [1].

Korpinen and Pääkkönen carried out in 2002 [2] an extensive enquiry, to study the working-age populationïs self-reported symptoms associated with using mobile phones and other electrical devices. Their research questions were: (1) how the respondents described their symptoms associated with the use of mobile phones and other electrical devices, and (2) if the answers could be classified into subgroups based on symptoms or devices. The questionnaire was sent to 15,000 Finns and 6121 (41%) responses were received. Three different subcategories could be formed: (1) respondents with different self-reported symptoms which they associated with using mobile phones, (2) respondents who had skin symptoms associated with long term computer use, and (3) respondents who had somatic symptoms associated with using mobile phones and other electrical devices [2]. From the point of view of the current study, it is interesting that in the enquiry made by Korpinen and Pääkkönen in 2002 it was still possible to find a clear uniform group of respondents claiming that they responded to computer screens. It looked like the phenomenon observed already in the early 1980s had emerged to stay.

Gangi and Johansson have found that several persons working at VDUs had both subjective and objective skin- and mucosa-related symptoms, for example itch, heat sensation, erythema, papules and pustules. Persons who suffered from the functional impairment electrohypersensitivity (EHS) had in their skin similar damages to those known to be affected by UV light or ionizing radiation [3]. The most common finding in the samples taken from the facial skin of persons

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getting symptoms of electrohypersensitivity was an increase of mast cells and their markers, histamine, tryptase and chymase. These findings can explain the clinical symptoms of pain, itch, edema and erythema [4].

The old cathode ray tube (CRT)-type monitors exposed their users to strong electric and magnetic fields. These monitors used an electron beam to form the image on phosphorescent dyes lining the inner surface of the cathode ray tube. High voltages were needed to accelerate the electron beam to required energies for sufficient phosphorescence and strong electromagnets were used to deflect the beam to create the required image patterns.

Liquid crystal display (LCD) screens used today are based on electronic control of liquid crystals. The background light source in LCD screens is typically a cold cathode fluorescent lamp or a series of light emitting diode (LED) modules. LCD screens do not produce as strong electromagnetic fields as CRT screens due to their relatively low voltages and currents. LCD screens can, however, contain significant digital integrated circuitry and switching power sources which create radiofrequency electromagnetic emissions. Several persons report that they still get symptoms while working at a computer with an LCD screen. The symptoms experienced by the persons are not only caused by the radiation of screens but also that of central processing units and peripherals. Many parts of the computer can increase the electromagnetic load on a user. Our working hypothesis was that the shielding of electromagnetic fields might reduce the symptoms.

WHO in 2005 published a document "Electromagnetic fields and public health" in which it stated that electromagnetic hypersensitivity symptoms that are commonly experienced include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (tiredness, fatigue and concentration difficulties). In Sweden the prevalence of EHS was first estimated at 1.5% [5] and a newer estimate is 2.6–3.2% [6]. In Austria the prevalence was estimated to be less than 2% in 1994 but it had increased to 3.5% in 2001 [7]. In Switzerland 5% of the population has been estimated to suffer from EHS [8]. In California the prevalence of self-reported sensitivity to electromagnetic fields was 3.2% and with 24.4% of those surveyed reporting sensitivity to chemicals as well [9]. Finally, the Canadian Human Rights Commission reported that approximately 3% of Canadians have been diagnosed with environmental sensitivities, including chemicals and EMF in their environment [10]. In the report the author especially recommended improving the environmental quality at work places. WHO recommended that the treatment of affected individuals should focus on the health symptoms and the clinical picture. In the treatment program, demands of affected individuals should not be considered, if they asked for reducing electromagnetic fields in the workplace or home (!). If the symptoms associated with electromagnetic fields become prolonged and severe, then according to WHO, the symptoms could be reduced by offering cognitive therapy as a treatment [11]. Hillert in 2001 [12] however clearly demonstrated this to be without effect.

The aim of the present study was to clarify the effect of reduction the electromagnetic irradiation by shielding the computer emitted irradiation with physical design on the users' self reported sensations.

2. Materials and methods

2.1. Design of the shielding cabinet

The shielding cabinet was designed by one electrosensitive subject with the help of a radio engineer. The cabinet was constructed out of 1 mm thick rolled steel. The sheets were shaped by cold pressing for rigidity and then welded together with continuous seams. The main door was manufactured from the same material and had two locking latches which, when closed, apply considerable pressure against the electrically conductive door seals. The compressible door seals are crucial for proper EMC (electromagnetic compatibility) sealing. All electrical contact areas of the steel chassis were left unpainted to ensure a galvanic connection.

The front window was a 3 mm thick sheet of Optolite Shielded HSR (by Instrument Plastics, UK) with a 0.25 mm pitch steel mesh laminated inside. The specified attenuation for the window is above 60 dB at the relevant frequencies. To reduce moire effects the mesh inside the window had an offset rotation of 10 degrees. The conductive window edges were galvanically connected to steel mesh layer inside the window. The window edges were connected to the steel chassis by compression against the chassis by a rectangular steel bracket. A total of 44 evenly spaced tightening screws ensured that the bracket applied an even pressure against the brittle window.

The cables were run through a square 10 cm × 10 cm cut-out opening on the back wall of the cabinet. Cables were inserted through the opening after which a steel panel was re-inserted over the opening and tightened with 8 screws. Electrically conductive seals help to maintain EMC integrity.

The cabinet materials offered a good isolation against radiofrequency emissions and low-frequency electromagnetic fields when fully sealed. The imperfect mating surfaces of the main window, the main door and the cable aperture cause, however, some leakage. A major electromagnetic compatibility (EMC) issue is the cable opening and the cables which penetrate the shielding. The conductors in the cables were electrically isolated from the metal chassis and they can act as signal conductors both into and out of the cabinet.

In the measurements we tested the cabinet by using a personal computer and its 230 V power supply in the cabinet. The mains voltage power cord ran through the cable aperture EMC shield. The laptop used an unearthed power supply and did not have access to additional direct grounding.

Fig. 1. Reference emission measurement setup inside the shielded room of EWC laboratory.

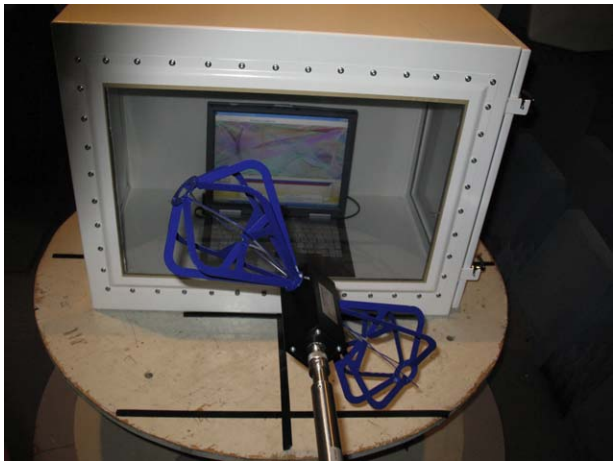

Fig. 2. The laptop inside the shielding cabinet.

2.2. Evaluation of the shielding efficacy

The attenuation of the shielded computer cabinet was measured in the shielded room of the EMC laboratory, Turku University of Applied Sciences (TUAS). RF frequencies from 10 MHz to 3 GHz were recorded with a test receiver (R&S ESPI, Germany). Two series of measurements were performed, first with the unshielded personal computer and then the personal computer inside the shielded cabinet. During the measurements the cabinet was earthed to the power mains protective earth. The antennas were located in the front of the computer and the cabinet, roughly in the location where the user's lower face or upper chest would be during normal computer operation.

The personal computer used in the measurements was a Fujitsu-Siemens Lifebook C1020 manufactured in 2004. To simulate the worst case emissions the laptop was running CPU and hard drive stressing software. No peripherals were used for these measurements and the only components were the laptop and the power supply.

The measurement in the frequency range of 10–1000 MHz was carried out using a Schaffner DPA 4000A antenna and frequency range of 1000–3000 MHz was measured using a Schaffner DPA 3000. The antennas had respective nominal frequency ranges of 200–1000 MHz and 1000–2800 MHz, outside of which the performance of the antennas was not guaranteed by the manufacturer. Especially the received spectrum components considerably below 200 MHz were not accurate and were further attenuated by the rapid loss of gain and matching in the antenna. Measuring emissions above 3000 MHz were not considered a priority as the strength of spectrum components fell below the measurement system noise floor towards 3000 MHz.

The antennas were positioned in 50 cm distance horizontally from the center of the laptop and at a height of 100 cm. The center of the antenna is was 60 cm from the laptop geometric center. Fig. 1 visualizes the physical layout of the measurement setup for the unshielded reference case. For the shielded case the laptop was inside the cabinet and positioned on the same spot as in the unshielded measurements. The front side of the cabinet was 6 cm beyond the edge of the laptop towards the antenna. The positioning of the laptop and the cabinet for the shielded case are shown in Figs. 2 and 3.

By comparing the measurements between the reference unshielded case and the shielded case one can estimate the level of shielding introduced by the cabinet enclosure. Fig. 4 shows the measured spectrum power for 10–1000 MHz without shielding and Fig. 5 shows the same measurement for the shielded situation respectively. Figs. 6 and 7 show the unshielded and shielded measurements for the frequency range of 1000–3000 MHz. The shielding attenuated emissions in front of the cabinet by up to 20 dB in the 10–1000 MHz range. The 300 kHz RBW was chosen to reliably capture all emission lines in the 8001 point sweep both in the 10–1000 MHz and 1000–3000 MHz ranges.

Fig. 3. A view into the open shielding cabinet with the cable access panel visible behind the laptop.

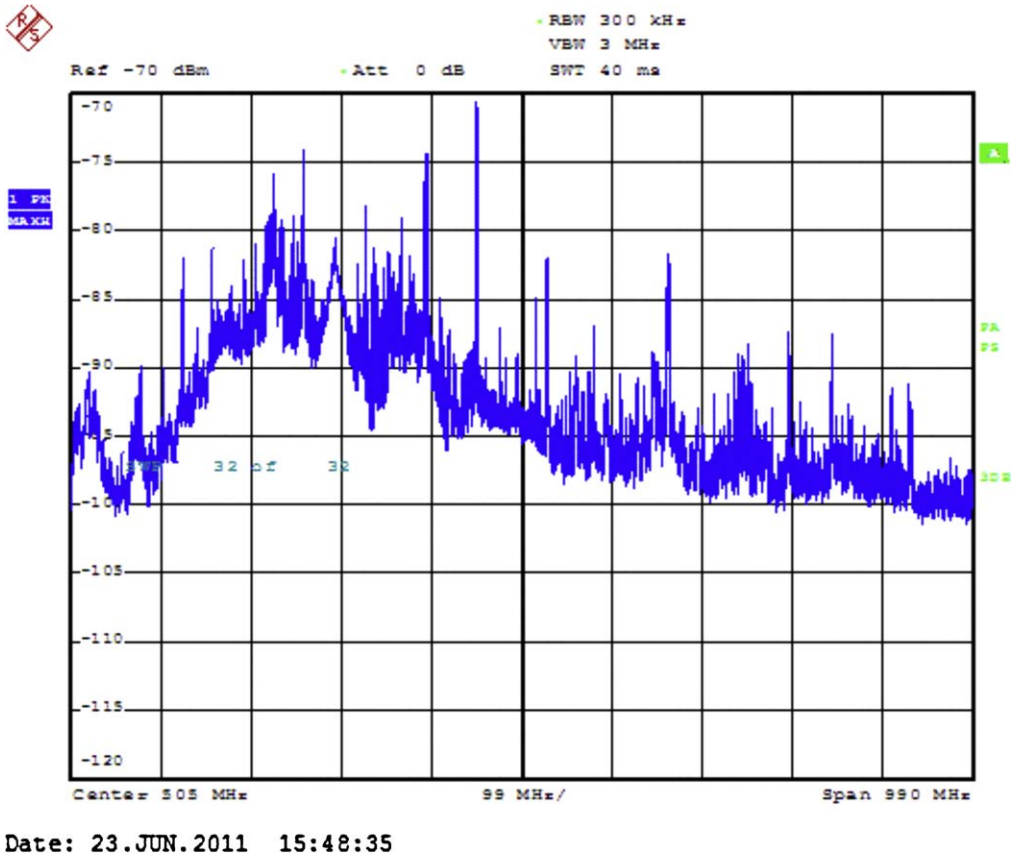

Fig. 4. Emissions of an unshielded personal computer for 10–1000 MHz.

2.3. Volunteers

Five persons who had reported health hazards while working with their computers volunteered to participate in the study. Three were men and two females. Their anthropometric characteristics are given in Table 1. One of the subjects was obese while the others had normal body mass index (BMI). They reported to be otherwise healthy and had no symptoms except those related to their computer work. The volunteers reported that they had had various symptoms for 4–21 years which they considered to be due to their computers (Table 2). All had various skin problems, headache, fatigue and two

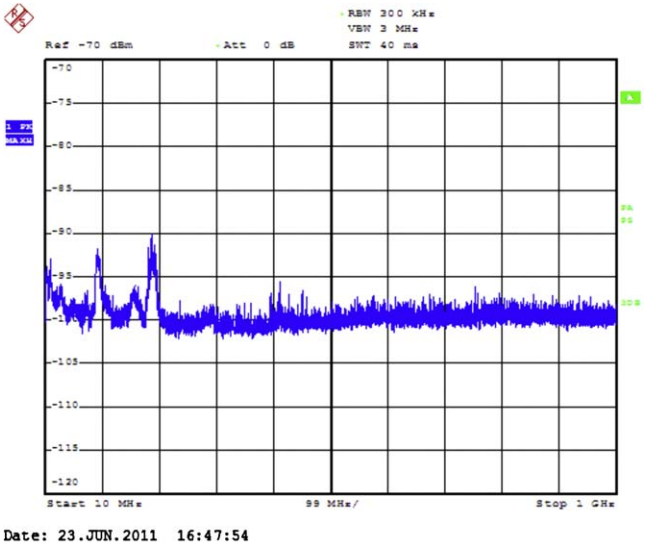

Fig. 5. Emissions of the shielding cabinet at 10–1000 MHz.

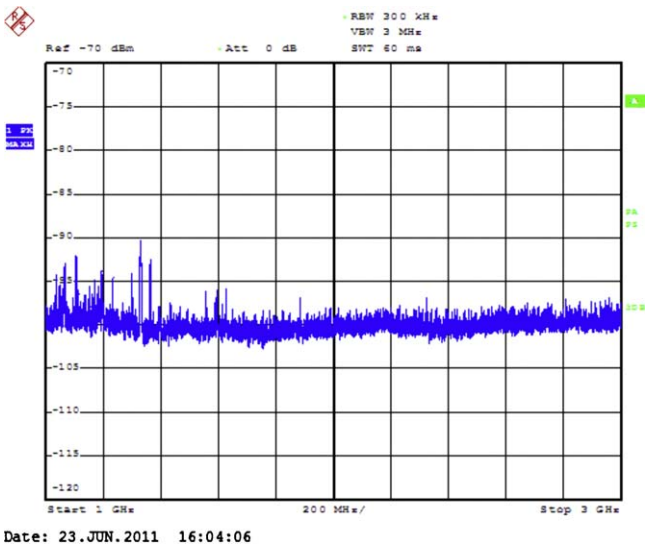

Fig. 6. Emissions of an unshielded personal computer for 1000–3000 MHz.

Table 1
Characteristics of the volunteers participating in the study.

Subject	Sex (m/f)	Age (years)	Weight (kg)	Height (cm)	Body mass index	Symptoms
1	f	55	92	163	34.6	Erythema, tingling and burning sensations, urticaria, shortness of breath, arrhythmia, fatigue and nausea
2	m	51	69	180	21.3	erythema, numbness of the skin, back pains, memory problems, emotional
3	m	50	82	186	23.7	Erythema and itching of the skin, shortness of breath, arrhythmia, memory and concentration problems, headache, blurred eyesight
4	m	48	54	171	18.5	Limb pains, muscle stiffness, headache
5	f	36	77	177	24.6	Burning sensations, redness and increased temperature of the skin, shortness of breath

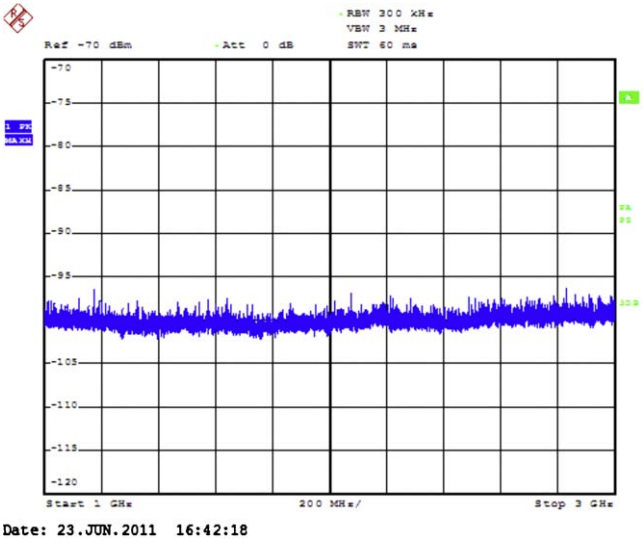

Fig. 7. Emissions of the shielding cabinet at 1000–3000 MHz.

reported memory problems and shortness of breath and one also pains and muscle stiffness.

The second subject was a 51-year-old male who reported he experienced erythema and numbness appearing on his face, hands, and sometimes all over his body while using a computer. He also told that he had back pains in his back at computer work. This subject also suffered from memory problems while working at the computer. He had difficulties retrieving data from his memory and also memorising things became difficult. The subject observed that while he was working at the computer, his emotional life became shallow, aesthetic sense disappeared and also associative thinking became 'stiff'.

The fifth subject was a 36-year-old female, whose major symptoms were skin symptoms like burning sensations of skin. Especially in the skin of the face, neck and arms there were red. Skin damages looked like burns, observed both subjectively and objectively. After the subject had been working at the computer, her skin felt exceptionally hot as if the skin had been feverish. She also had shortness of breath which was experienced by the first and the third subjects, too.

Each subject had a shielding computer cabinet at disposal and all of them used laptop computers with the cabinet. Either the laptop or a separate screen for the laptop could be put in the cabinet. If only the screen was put in the cabinet, then the computer was located as far as possible from the user given the cable length limitations. The first subject put only the screen in the cabinet. The second and the third subject put the laptops into the cabinets. The fourth and the fifth subjects put separate screens in the cabinets. In all cases an external keyboard and a mouse were used in front of the cabinet.

Table 2
Summary of symptom durations and improvements due to using the shielding cabinet of the computer.

Subject	Time since first symptoms	Duration of cabinet use	Benefits
1	9 years	1 week	Slight alleviation of nausea
2	21 years	7 years	Disappearance of all symptoms, can use a computer full-time
3	4 years	2 months	Improvement of all symptoms and quicker recovery time from computer related symptoms
4	6 years	3 months	Considerable alleviation of symptoms, able to use the computer for hours
5	7 years	1 year	Became symptomless and is able to work full-time with a computer

3. Results

The first subject, a 55-year-old female, had been suffering from computer-related symptoms for 9 years. For the current study, she spent only 1 week on using the shielding computer cabinet. However, she told us that at the computer without the cabinet she often felt undefined nausea that had slightly been alleviated when she had started working with the shielding cabinet.

The second subject, a 51-year-old male, told that he had responded to the electromagnetic fields produced by computers as long as for 21 years. Therefore, he had already been using a solution comparable to the shielding computer

cabinet for 7 years. He told that immediately after the introduction of the computer cabinet, all his symptoms had been alleviated. The subject reported that thanks to the cabinet, he did not observe any of his previous symptoms and was able to work on the computer full-time.

The third subject, a 50-year-old male, reported getting slight symptoms from electromagnetic fields of computers for 20 years, but in the past 4 years his symptoms had become so serious that he was unable to work. For the current study he had been using the shielding computer cabinet for 2 months and he told that his diverse symptoms had been alleviated and recovery from the symptoms had also become quicker. Only the skin symptoms caused by computers had continued in the same way as before.

The fourth subject, a 48-year-old male, said to have had responded to the electromagnetic fields of computers for 6 years. He used a shielding computer cabinet for the current study for 3 months. During this time his symptoms were alleviated remarkably. He described that without the cabinet he was able to work on the computer for only 15–30 min before he started to get muscular pain and tension. Thanks to the cabinet, he was able to use the computer for several hours.

The fifth subject, a 36-year-old female, reported that she had been responding to the electromagnetic fields of computers for 7 years. Her symptoms had become insufferable after she had started working on a computer full-time. For the current study she tried a shielding computer cabinet for a year. Using it had removed her breathing symptoms immediately. Skin symptoms had also been alleviated after she had started to use the shielding cabinet. After using it for 2–3 months, she reported that her skin had started to heal and now she is able to use the cabinet shielded computer full-time. Without the cabinet she is not able to work because her skin symptoms started gradually to return.

4. Discussion

Our physical measurements showed that the designed shielding computer cabinet clearly decreased the electromagnetic irradiation. The volunteers reported that they had noticed various symptoms due to the computer work for more than 4 years. As the time of shielding cabinet use varied from 1 week to months and years, one can see that the computer users benefitted more and more with time it was used. The shielding cabinet permitted even daily computer work, if it had been used for than 1 year or more. If the shielding cabinet had been used for only 2 or 3 months already significant increase of working time and more speedy recovery was reported. Thus the recovery required time and was slow. This is easy to understand as the reported symptoms had lasted years. In any case the results suggest that complete recovery is possible, if regular shielding was used. As the main emphasis of this study has been physical protection, more studies with volunteers are needed to clarify which organ system responds earlier and which organs require more time to recover.

Our results indicate the appropriately controlled provocation studies are important to establish the factors that drive and support the functional impairment electrohypersensitivity. Present results also help to understand the relative importance of psychological and non-psychological processes in mediating observed symptoms. One way to establish a causal relationship is to introduce the provocative agent in question, but likewise – as studied here – a very powerful tool can be to reduce or eliminate the very same physical factor, in this case the electromagnetic irradiation. A working laboratory definition of electrohypersensitivity formulated in symptomological terms is therefore needed to permit recognition of hypersensitivity reactions when they occur. In previous provocation studies [cf. Ref. 13], the assumption was made that true hypersensitive subjects would exhibit more or less the same symptoms in response to repeated provocations. The functional impairment is by definition always individual, personal and private. We therefore defined electrohypersensitivity as the occurrence of any medically recognized symptom in response to provocation using an environmentally relevant electromagnetic irradiation-source, such as a personal computer; there was no requirement that the same symptom must reoccur when the electromagnetic field re-occurred. This definition avoided the problem of masking real effects and more appropriately matched the laboratory procedure to the known characteristics of electrohypersensitivity.

Current results in the general literature clearly show that people are suffering various symptoms, even losing their jobs, and furthermore, having to pay for protection from electromagnetic irradiation. For those people it acts as an actual barrier that disturbs their social participation and well-being. In Sweden, EHS is recognized as a functional impairment, therefore, EHS persons can receive assistance and service in accordance with the Swedish Act concerning Support and Service for Persons with Certain Functional Impairments (“LSS-lagen”) and the Swedish Social Services Act (“Socialtjänstlagen”) [6]. “*The UN 22 Standard Rules on the equalization of opportunities for people with disabilities*” (1993), since 2007 upgraded into “*The UN Convention on Human Rights for Persons with Functional Impairments*” guarantees complete accessibility to people with disabilities. The stance assumed by the WHO violates the rights of functionally impaired people and for this reason it should be amended.

The government of Sweden considers changing the environment as primary solution, because in Sweden impairments are viewed from the point of the environment. This view is expressed in the Swedish Action Plan for Persons with Impairments (prop. 1999/2000:79 “Den nationella handlingplanen för handikappolitiken – Från patient till medborgare”). It is considered that no human being is in itself impaired, but instead there are shortcomings in the environment which cause the impairment.

The European Parliament has published a report that requires information about the locations of electromagnetic irradiation sources, such as mobile phone base stations and powerlines, to recognize EHS persons and to grant them adequate protection [14]. The report indicates 29 countermeasures including the above-mentioned items, including bullet point no. 28. "Calls on Member States to follow the example of Sweden and to recognize persons that suffer from electrohypersensitivity as being disabled so as to grant adequate protection as well as equal opportunities".

In the USA, the Architectural and Transportation Barriers Compliance Board has stated EHS and MCS to be considered as disabilities under the Americans With Disabilities Act [15]. Furthermore, the National Institute of Building Sciences, in the USA, has recommended to provide rooms with low chemical and EMF levels in commercial and public buildings. The purpose is to ensure accessibility for MCS and EHS persons [16].

As stated above, it is necessary to take a precautionary approach and to provide social support, as well as to conduct further research to understand the relationship between health symptoms and irradiation. Our current study shall be viewed against this background.

Two out of the five volunteers participating in the study became totally able to work after using the cabinet damping the electromagnetic radiation of the computer for 1 year or more. Symptoms of the other two volunteers participating in the study were alleviated after using the shielding cabinet for 2 or 3 months, but they were not completely symptom free. The one volunteer had only a week's time to use the shielding cabinet but despite the short test time, also she reported slight alleviation for her symptoms. On grounds of the study that we have conducted, there is reason to suppose that reducing electromagnetic fields strongly reduced the health hazards of the subjects. On the strength of this study result, we hope that WHO will revise its recommended instructions [11] for treating electrohypersensitive individuals and rather start changing their environment into one with complete and equal accessability.

In conclusion: the present results showed that the shielding protection against irradiation is efficient way to reduce of computer emissions. That is the only reasonable way to help people suffering from the electromagnetic irradiation of computers emit. It is also a highly cost-effective measure to get people back into work, rather than to continue their lengthy sick-leaves and inability to continue in their profession.

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