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Individual Whole Body and Organ Specific Exposure for Near-Field and Far-Field Exposure of Radio Frequency Electromagnetic Fields

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INTRODUCTION

The individual exposure of a person is the sum of contributions from different near-field (NF) and far-field (FF) sources. NF sources include all devices operating in the close vicinity of the human body (e.g. self-usage of a mobile phone) and can cause temporarily high local exposure, whereas FF sources (e.g. base stations) usually lead to lower but rather continuous exposure levels.

In epidemiological studies, personal exposure meters are often used to quantify the total exposure from different sources. However, personal exposure meters are not suitable to measure NF sources, as the measurement depends heavily on the distance between the emitting device and the exposimeter. Thus, personal measurements cannot inform about the relative importance of NF and FF sources to the total whole body averaged (WBA) and the organ specific averaged (OSA) specific absorption rate (SAR). In this study the contributions from various NF and FF sources of the everyday environment are numerically determined and compared using realistic data on personal RF-EMF exposure and mobile phone use from a population based cohort study in Switzerland (QUALIFEX), see [1].

MATERIALS AND METHODS

The WBA SAR and the OSA SAR for both NF and FF sources are numerically evaluated using the Virtual Family Man model [2] and the commercially available simulation platform SEMCAD X.

For the assessment of FF exposure, the anatomical model was irradiated by plane waves incident from the six major directions (top, bottom, front, back, left and right side) at two polarizations each at 100 MHz, 650 MHz, 900 MHz, 1800 MHz, 1950 MHz and 2450 MHz. The peak spatial SAR, the WBA SAR and the OSA SAR were calculated for a total normalized power flux density of 1 W/m². These results were weighted according the mean radio frequency (RF) electromagnetic field (EMF) exposure (power flux density) of the 131 participants of the exposimeter study carried out in the framework of the QUALIFEX study. The mean contribution of different sources to the whole FF exposure without own phone use is given in [3]. Please note that the exposure caused by other mobile phone users is also included in the FF exposure. The total WBA and OSA SAR were finally calculated by the sum of the SAR values of different services. For NF exposure, the human model was exposed to a mobile phone attached to the head operating at 900, 1750 and 1950 MHz. Results were normalized to an input power of 1 Watt. The simulated WBA SAR and the OSA SAR were weighted according to the average call time of the QUALIFEX participants of 25.6 minutes per week and an average output power of 133 mW for GSM 900 and 62.2 mW for GSM 1800 (see [4]). For UMTS an average transmission power of 650 µW was chosen assuming that 50% of the phone calls are made indoor (buildings) and 50% outdoor (big city), see [5].

RESULTS

The induced WBA SAR caused by FF sources sums up to 407 nW/kg. In comparison, an
average mobile phone user (25.6 min/week) causes a self-induced WBA SAR of 2 µW/kg, when using the GSM 900 service exclusively. Using GSM 1800 or UMTS causes an induced WBA SAR of 1.26 µW/kg and 12.6 nW/kg, respectively.

Figure 1 (left) shows the ratio between NF and FF WBA SAR for three cases, i.e. the entire NF exposure is caused by either a GSM 900, GSM 1800 or UMTS phone. The results show that the WBA SAR for NF is 7.1 dB higher than for FF exposure if GSM 900 is used. Using the GSM 1800 service leads to a difference of 4.9 dB and for UMTS to -15.1 dB.

In order to encounter the same WBA SAR for NF and FF sources the call time for a GSM 900 and GSM 1800 phone has to be decreased from 25.6 min/week to 5 min/week and 8.3 min/week, respectively. In comparison, if only a UMTS phone is used, the call time can be increased to 13.8 hours/week.

Figure 1 (right) shows the ratio of the OSA SAR for 5 selected organs for NF and FF exposure. The results show that brain organs like brain grey-matter and brain white-matter encounter a smaller exposure by a UMTS phone when compared to the induced exposure caused by FF sources.

CONCLUSIONS

The WBA SAR of an average mobile phone user (25.6 min/week) is dominated by the use of his or her own mobile phone when a GSM 900 or GSM 1800 phone is used. However, for a UMTS phone the FF sources feature the dominant contribution to the WBA SAR. For OSA SAR there are brain organs that encounter a smaller exposure by NF than by FF sources, when a UMTS phone is used exclusively.

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