STUDENT PAPER

Personal exposure from mobile phone base stations in Australia and Belgium

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We employed an on-body calibrated personal distributed exposimeter to assess micro-environmental personal exposure to mobile phone base stations GSM 900 MHz downlink in Australia and Belgium. The study revealed that the personal exposure levels measured in Australian microenvironments were generally lower than those in the Belgian microenvironments. The personal exposures across urban microenvironments were higher than those in the rural and suburban microenvironments. Likewise, the exposure levels across the outdoor microenvironments were much higher than those across the indoor microenvironments. A majority of the second measurements in the same site provided highly varied exposures.

Introduction

Mobile phone base stations are a major source of whole body exposure to RF-EMF (Bolte and Eikelboom, 2012; Frei et al., 2009; Gajšek et al., 2015; Joseph et al., 2010). A personal distributed exposimeter (PDE) with multiple RF-EMF antennas, placed on the body, has been developed recently so as to reduce measurement uncertainties related to shielding effects and directionality of the signal (Thielens et al., 2015a; Thielens et al., 2015b; Thielens et al., 2013; Vanveerdeghem et al., 2015).

The purposes of this study were: i) to measure personal exposure in the Global System for MobileCommunications (GSM) 900 MHz downlink (DL) frequency band with an on-body calibrated PDE (a novel exposimeter), and ii) to compare the exposure levels for selected microenvironments in Australia and Belgium.

Methods

The measurements were performed by a single person (CB) during 27th March–8th May 2015. The study regions in Australia covered the Greater Melbourne region, and a rural site. Similarly, Gent and Mol, the provinces of East Flanders and Antwerp respectively, in the Flemish region of Belgium were covered in the study. A total of 34 matched microenvironments (17 in Australia and 17 in Belgium) were chosen to evaluate personal exposures.

The PDE system was used to perform personal exposure measurements. The PDE system was a collection of three body-worn antennas (2 anterior and 1 posterior) tuned to the mobile phone GSM 900 MHz DL frequency band. The PDE antennas were attached to a T-shirt; 2 front antennas (1 over the right chest, the other on the left abdominal area), and 1 posterior antenna on the central back (Fig. 1).

Medians electric field strengths (E_{rms} in V/m) were calculated from the geometric means of the PDE. The personal exposures across similar microenvironments in Australia (n=14) and Belgium (n=14) were compared. The assessment of exposure variability during the first and second measurements was also done. Thirteen microenvironments in Australia and 6 microenvironments in Belgium, which had repeated measurements, were [illegible]

For all statistical tests, the p <0.05 (two sided) was considered as statistically significant. All data analysis was carried out using MATLAB R2015a (The MathWorks Inc, Natick, Massachusetts, USA) or STATA ver13.1 (StataCorp, College Station, TX, USA).

Results

In Australia, the five highest median exposure levels (from mobile phone base stations) measured were: city centre (0.248 V/m), bus (0.124 V/m), railway station (0.105 V/m), train (0.055 V/m), and residential outdoor (urban) (0.44 V/m). Similarly, the five lowest median exposures measured were: car (urban/suburban) (0.006 V/m), residential outdoor (rural/suburban) (0.006 V/m), bicycle (urban) (0.017 V/m), office indoor (urban) (0.018 V/m), and residential indoor (urban) (0.019 V/m).

In Belgium, the five highest median exposures measured were: bicycle (urban) (0.238 V/m), tram station (0.238 V/m), city centre (0.156 V/m), residential outdoor (urban) (0.139 V/m), and park (0.124 V/m). Similarly, the five lowest exposure levels measured were: bicycle (rural/suburban) (0.012 V/m), residential outdoor (rural/suburban) (0.014 V/m), car (rural/suburban) (0.016 V/m), residential indoor (rural/suburban) (0.017 V/m), and train (0.020 V/m).

We found that personal exposures across most of the microenvironments in Australia were significantly lower ($p<0.05$) than the exposure across the microenvironments in Belgium. However, there were a few microenvironments where the exposure in Australia was higher ($p<0.05$) than the corresponding exposure in Belgium. For instance, the city centre results in Melbourne were significantly higher ($p<0.001$) than the exposure level at the city centre of Gent, as were exposures in the Melbourne train and during a bus ride, than those in Gent.

The majority of the microenvironments (13 of 19) provided significantly different median exposure levels at the measurements 1 and 2, suggesting that both measurements had highly varied exposures.

Discussion

To our knowledge, this is the first microenvironmental exposure study to evaluate RF-EMF exposures with the use of a novel, on-body calibrated system of exposimeter, with multiple antennas. The study also provides a basis for a direct valid comparison of exposures across the microenvironments in Australia and Belgium with different geophysical, environment and weather conditions.

The exposure levels found in our study were well below the reference levels for the general public as provided in the guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998). The median exposures in Australia measured were in the range of 0.02–3.65 % of the reference level, whereas those in Belgium were in the range of 0.03-2.73 % of the reference level.

In general, the exposures measured across most microenvironments in Australia were much lower than those measured across similar microenvironments in Belgium. Higher population density and building characteristics (densely sited and fewer tall buildings) may have attributed to the higher observed exposures across most of the microenvironments in Belgium (Gent) compared to those observed across the microenvironments in Australia (Melbourne).

It was also observed that the personal exposures in urban microenvironments were much higher than those in rural and suburban microenvironments in both Australia and Belgium. Furthermore, the exposure levels across indoor microenvironments were much lower than those across the outdoor microenvironments.

The exposure levels found in our study are comparable to those reported by previous studies conducted in Belgium and other parts of Europe (Joseph et al., 2010; Urbinello et al., 2014a, 2014b).

Conclusion

An on-body calibrated PDE was employed to assess micro-environmental personal exposure to mobile phone base stations GSM 900 MHz downlink in Australia and Belgium. The study revealed that the personal exposure levels measured in Australian microenvironments were generally lower than those in the Belgian microenvironments. The personal exposures across urban microenvironments were higher than those in the rural and suburban microenvironments. Likewise, the exposure levels across the outdoor microenvironments were much higher than those across the indoor microenvironments. A majority of the second measurements in the same site provided highly varied exposures.

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Figures

a b c

Figure 1. A human subject performing i) an on-body calibration of the PDE (figures a & b), in Gent, Belgium, ii) exposure measurement at a site in Melbourne, Australia (figure c)