Environment International 121 (2018) 297–307

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Individual variation in temporal relationships between exposure to radiofrequency electromagnetic fields and non-specific physical symptoms: A new approach in studying 'electrosensitivity'

R.P. Bogers[a,*], A. van Gils[b], S.C.S. Clahsen[a], W. Vercruijsse[a,1], I. van Kamp[a], C. Baliatsas[a,2], J.G.M. Rosmalen[b], J.F.B. Bolte[a,c]

[a] National Institute for Public Health and the Environment (RIVM), PO Box 1, 3720 BA Bilthoven, the Netherlands
[b] University of Groningen, University Medical Center Groningen, Interdisciplinary Center Psychopathology and Emotion regulation (ICPE), PO Box 30.001, Hospital mail address CC72, 9700 RB Groningen, the Netherlands
[c] The Hague University of Applied Sciences, Faculty of Technology, Innovation, and Society, Smart Sensor Systems group, Rotterdamseweg 137, 2628 AL Delft, the Netherlands

ARTICLE INFO

Handling Editor: Olga-Ioanna Kalantzi

Keywords:
Electromagnetic sensitivity
Idiopathic environmental intolerance (IEI-EMF)
Non-specific physical symptoms (NSPS)
Electromagnetic fields
EMF
Personal exposure measurements

ABSTRACT

Background: Everyday exposure to radiofrequency electromagnetic fields (RF-EMF) emitted from wireless devices such as mobile phones and base stations, radio and television transmitters is ubiquitous. Some people attribute non-specific physical symptoms (NSPS) such as headache and fatigue to exposure to RF-EMF. Most previous laboratory studies or studies that analyzed populations at a group level did not find evidence of an association between RF-EMF exposure and NSPS.

Objectives: We explored the association between exposure to RF-EMF in daily life and the occurrence of NSPS in individual self-declared electrohypersensitive persons using body worn exposimeters and electronic diaries.

Methods: We selected seven individuals who attributed their NSPS to RF-EMF exposure. The level of and variability in personal RF-EMF exposure and NSPS were determined during a three-week period. Data were analyzed using time series analysis in which exposure as measured and recorded in the diary was correlated with NSPS.

Results: We found statistically significant correlations between perceived and actual exposure to wireless internet (WiFi - rate of change and number of peaks above threshold) and base stations for mobile telecommunications (GSM + UMTS downlink, rate of change) and NSPS scores in four of the seven participants. In two persons a higher EMF exposure was associated with higher symptom scores, and in two other persons it was associated with lower scores. Remarkably, we found no significant correlations between NSPS and time-weighted average power density, the most commonly used exposure metric.

Conclusions: RF-EMF exposure was associated either positively or negatively with NSPS in some but not all of the selected self-declared electrohypersensitive persons.

1. Introduction

The term non-specific physical symptoms (NSPS) refers to symptoms such as headache, fatigue and dizziness that cannot be explained by a medical condition (Barsky and Borus, 1999; Henningsen et al., 2011; Korber et al., 2011; Kroenke and Price, 1993). NSPS are sometimes attributed to the exposure to radiofrequency electromagnetic fields (RF-EMF) emitted from wireless devices and mobile telecommunication transmitters, but there is no convincing evidence for an association between exposure to RF-EMF and NSPS in the population

Abbreviations: NSPS, non-specific physical symptoms; RF-EMF, radiofrequency electromagnetic fields; DECT, digital enhanced cordless telecommunications

* Corresponding author at: National Institute for Public Health and the Environment, Centre for Sustainability, Environment and Health, PO Box 1, 3720 BA Bilthoven, the Netherlands.

E-mail addresses: rik.bogers@rivm.nl (R.P. Bogers), a.van.gils@umcg.nl (A. van Gils), sander.clahsen@rivm.nl (S.C.S. Clahsen), wendy.vercruijsse@pbl.nl (W. Vercruijsse), irene.van.kamp@rivm.nl (I. van Kamp), c.baliatsas@nivel.nl (C. Baliatsas), j.g.m.rosmalen@umcg.nl (J.G.M. Rosmalen), john.bolte@rivm.nl, j.f.b.bolte@hhs.nl (J.F.B. Bolte).

[1] Present address: PBL Netherlands Environmental Assessment Agency, PO Box 30314, 2500 GH Den Haag, the Netherlands.

[2] Present address: Netherlands institute for health services research, PO Box 1568, 3500 BN Utrecht, the Netherlands.

https://doi.org/10.1016/j.envint.2018.08.064
Received 17 May 2018; Received in revised form 28 August 2018; Accepted 28 August 2018

(Augner et al., 2012; Baliatsas et al., 2012a; Roosli et al., 2010; Rubin et al., 2011; Rubin et al., 2010). Because the origin of the symptoms is unclear, the WHO introduced the term Idiopathic Environmental Intolerance with attribution to EMF (IEI-EMF) (World Health Organization, 2005). IEI-EMF (also referred to as electro(hyper)sensitivity) remains a poorly defined condition (Baliatsas et al., 2012b) for which an internationally recognized case definition is missing (Baliatsas and Rubin, 2014; Baliatsas et al., 2012b). Estimated prevalence rates range mainly between 3.5% and 8% (Baliatsas et al., 2014; Röösli et al., 2010; Schreier et al., 2006; Schrottner and Leitgeb, 2008; van Dongen et al., 2014), and sometimes over 13% (Meg Tseng et al., 2011; Mohler et al., 2010). In the Netherlands, about one third of general practitioners, occupational physicians and occupational hygienists have ever been consulted by patients who attribute their symptoms to EMF (Slottje et al., 2017). No consistent symptom patterns among individuals reporting IEI-EMF were found, but neurological symptoms seem to be more pronounced (Baliatsas et al., 2014; Hillert et al., 2002). Belpomme et al. (2015) found that people with IEI-EMF showed enhanced blood histamine levels. Psychosomatic processes might be associated with NSPS in IEI-EMF (Johansson et al., 2010; Koteles et al., 2012; Landgrebe et al., 2008; Rubin et al., 2008; Rubin et al., 2010; Witthoft and Rubin, 2013), not necessarily as a cause, but rather as conditioned response from the onset of symptoms, and reinforcing the attribution to EMF (Dieudonne, 2016). The variability of symptoms reactions between and within individuals could explain the lack of a clear association (Tuengler and von Klitzing, 2013). However, the possibility of a causal effect of RF-EMF exposure cannot be completely dismissed yet, because of methodological and conceptual limitations in previous studies (Baliatsas and Rubin, 2014).

Most studies into exposure-response associations, in IEI-EMF were short-term laboratory studies, only suitable to detect symptoms that are elicited by relatively short, acute exposure. Further, it might be possible that only in some individuals an associations exist between NSPS and EMF; statistical analyses at group level would not pick that up. The few studies on IEI-EMF that did examine persons on an individual basis were laboratory studies that repeatedly tested individuals, mainly to check whether they could perceive EMF exposure vs. sham exposure (Rubin et al., 2010). An alternative approach would be to study exposure response relations at an individual level over time, the so called idiographic approach (Barlow and Nock, 2009). Idiographic studies facilitate the detection of clinically relevant differences between individuals without compromising ecological validity, since data are collected in daily life situations. Time series analysis (Brandt and Williams, 2007) can be used to assess causal heterogeneity (Rosmalen et al., 2012), with repeated measures of the variables of interest, aiming to explain variance within single individuals, allowing for the identification of people who develop symptoms following exposure to EMF. This study explored the association between exposure to RF-EMF and NSPS at individual level in self-declared IEI-EMF persons while using an ambulatory design adapted to individual characteristics. The study tested the feasibility of an idiographic approach. Individuals with IEI-EMF were selected using theory-based selection criteria. The level of and variability in personal RF-EMF exposure and NSPS were determined, and time series analysis was used as the primary statistical approach.

2. Materials and methods

2.1. Design and procedure

The study was an ecological momentary assessment study in which, for 21 consecutive days, participants carried a measurement set consisting of an RF-EMF personal exposure meter, also referred to as an exposimeter, a global positioning system (GPS) logger, and an electronic diary. The electronic diary had to be filled out every 6 h by the participants at alarm cues in the morning, afternoon, and evening, and was used to assess NSPS and perceived exposure over the last 6 h.

All study materials (diaries, exposimeters, and instructions) were delivered at the participants' homes. The participants were orally instructed about the study procedures by field workers and signed an informed consent form. During the study period, the participants were visited four times. Handling of personal data complied with the Personal Data Protection Act [in Dutch: Wet bescherming persoonsgegevens (Wbp)].

2.2. Selection of study population

In this exploratory study we selected seven self-declared hypersensitive people attributing their NSPS to a clearly defined source of radiofrequency electromagnetic fields. Further, to detect any possible correlation, both exposure pattern and severity of symptoms should vary over time. Because it proved difficult to find a sufficient number of participants from our databases of previous studies, they had to be recruited in various ways. Firstly, participants from an ongoing study (Bogers et al., 2013) were requested to also participate in the present study. Secondly, invitations to participate were placed on Twitter, Facebook, and the website of the Dutch National Institute for Public Health and the Environment (RIVM). Thirdly, participants were recruited via professional contacts (e.g. via the community health services) and via other participants. Fourthly, announcements were placed in local newspapers. Recruitment continued until seven participants completed the measurement protocol. From all applications, participants were initially selected on the basis of a short questionnaire during a telephone interview. Supplement A shows the questionnaire. Briefly, the questionnaire included questions on attribution of physical symptoms to EMF, EMF sources that caused or worsened the symptoms, variation in presence and intensity of symptoms during the day, time lag between exposure and the occurrence of symptoms, engagement in situations with potentially high EMF exposure, and willingness to minimize use of a mobile phone during the study period. Applicants were selected if they attributed their symptoms to RF EMF exposure, if they were expected to show sufficient variation in both RF EMF exposure and symptoms during the study period, and if they agreed to minimize use of a mobile phone. Applicants with knowledge on their personal EMF exposure, e.g. because of the use of a personal exposure meter or previous EMF measurements at home, were excluded. Although a question on knowledge of exposure was initially not asked at the first telephone interview, it was asked at a subsequent contact moment as it turned out that some participants of the abovementioned ongoing study had already received a personal exposure report. Also persons who were diagnosed with depression, anxiety disorder, burnout, psychosis, chronic fatigue syndrome or fibromyalgia were excluded.

2.3. Personal RF-EMF exposure assessment

Actual EMF exposure was measured using EME-SPY 121 exposimeters (Satimo, Cortaboeuf, France) worn at the hip in a camera bag. The exposimeters measure the RF electric field strength in 12 frequency bands used for communication and broadcasting (see Supplement B).

For each of the exposimeters the laboratory of the Dutch Air Force determined a multiplicative calibration correction factor for all 12 frequency bands. The calibration measurements were performed in an anechoic chamber by measuring the response of the exposimeter to a standard, vertically polarised input signal of 2.5 V/m, with a frequency at the mid of a specific frequency band.

The exposure to EMF over fixed time intervals of 6 h prior to filling out the diaries in the morning, afternoon and evening was characterised in several metrics for central tendency and variability. The metric for central tendency was the time-weighted average (TWA) (FM, downlink base stations for mobile telecommunications, DECT), and for variability