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Simulation of PsSAR associated with the use of laptop computers as a function of position in relation to the adult body

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Abstract

The Specific Absorption Rate (SAR) is estimated in the body of a seated 34 year old male exposed to 2.4 GHz electromagnetic field (EMF) emitted by laptops. The laptop position is varied vertically and horizontally from the seated model in order to estimate the changes in SAR associated with changes in distance from the body. The estimated results are compared to the psSAR (peak spatial SAR) recommended exposure limits. The different SAR simulation situations are calculated using the Finite Difference Time Domain-FDTD employing the SEMCAD X software.

Introduction

The low level, long term exposure produced by wireless systems is a growing concern among researchers, governments and the general population. An important wireless system operating in the frequency range from 2400 MHz to 2483 MHz follows the IEEE standard 802.11 (WiFi) [1]. This technology is widespread in portable devices such as in laptop computers, tablets, and smart phones. Therefore, it is essential to develop realistic modeling that can be used to calculate absorption of radiofrequency (RF) radiation in terms of the Specific Absorption Rate (SAR).

What is SAR

The SAR is an estimation of the power absorbed per unity mass of the exposed tissue. The SAR measured in watts per kilogram or miliwatts per gram is widely used to quantify the EMF absorbed in biological tissues.

International Regulations

Issues about exposure limits, models, measurements and simulations of the SAR are recommended for some institutions: FCC [2], the ANSI/IEEE [3] and the ICNIRP [4]. Those institutions establish exposure rules for the non ionizing radiation frequency range.

This work presents

The SAR produced by laptop wireless computers in the body of heterogeneous models when an half wave dipole antenna and a planar inverted “F” antenna (PIFA) operating at 2.45 GHz are simulated. Two situations are studied:

1. The laptop is moved vertically in three positions from the lap with the radiating element located behind the keyboard.
2. The laptop is moved horizontally in three positions from the chest with the radiating element located behind the screen.

The SAR simulated results are compared to the exposure limits recommended by some international guidelines.

Methods

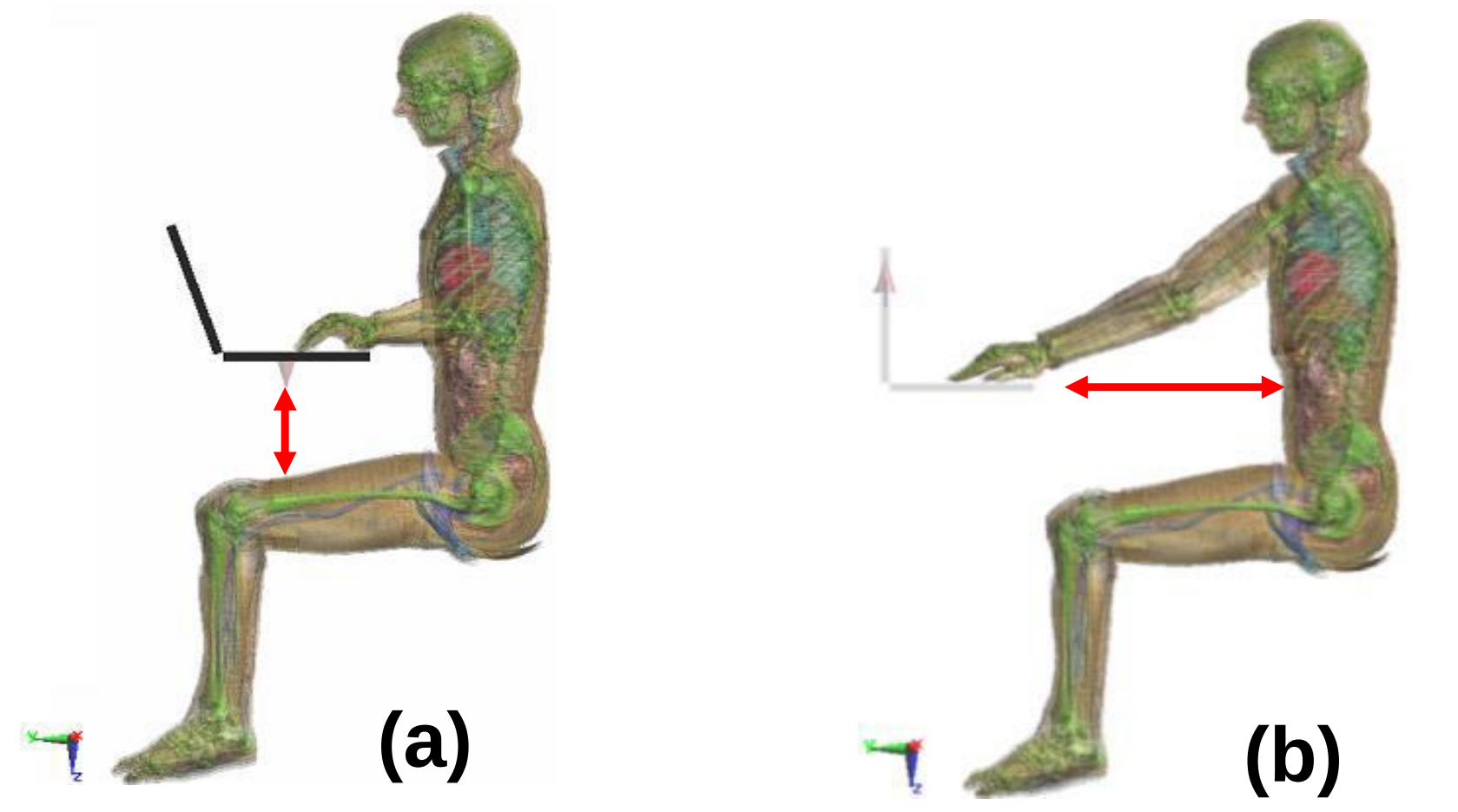
The SAR is simulated using SEMCAD X [5]. This software performs the finite difference time domain (FDTD) method which allows calculation of electromagnetic exposure due to WiFi devices. The FDTD method has proved to be one of the more efficient techniques to estimate RF absorption in dielectric tissues, especially when heterogeneous models are involved [6]. The SAR simulations were performed in the Cluster Sun Fire of the CESUP [7] and in a computer with i5 3470 CPU, 32 GB RAM and Nvidia Tesla C1060 Hardware at Communication Laboratory UFRGS.

In order to find a balance between grid dimensions, computational limitations and SAR measurement, reliability, some characteristics of the simulations are: more than ten cells per wavelength at the highest operation frequency (2.45 GHz) and absorbing layer conditions (ABC) were established to absorb around 90% of the incident EM energy.

The body model used is a 34 year old male adult named Duke [8]. Figure 1 shows the Duke (a high resolution heterogeneous model), which has 77 kg (weight), 1.74m (height), 77 types of tissues and 75 bones. The permittivity and equivalent conductivity for the different tissues were obtained from [9].

The power delivered to the radiating elements was normalized to 100 mW and they were located in the right rear part of the screen and on the right rear part of the keyboard in accordance with [10].

Fig. 1 - Model used in the simulation of the SAR: (a) Situation ‘1’ and (b) Situation ‘2’



Results

The results are presented in terms of peak spatial SAR (psSAR) for 1g and 10g. In the major part of the simulations, the psSAR were below the recommended exposure limits. However, parts of the body closest to the antennas, such as hands, lap and chest absorbs higher EM energy intensity. Especially at situation ‘1’, when the laptop is over the lap (0 cm). In this case the 10g psSAR was elevated: 1.4 W/Kg for PIFA and 3.02 W/Kg for dipole (table 1).

Fig. 2 - SAR distribution for situation ‘1’ with three distances between laptop and lap (0, 10, 20 cm respectively) for: (a) dipole and (b) PIFA.

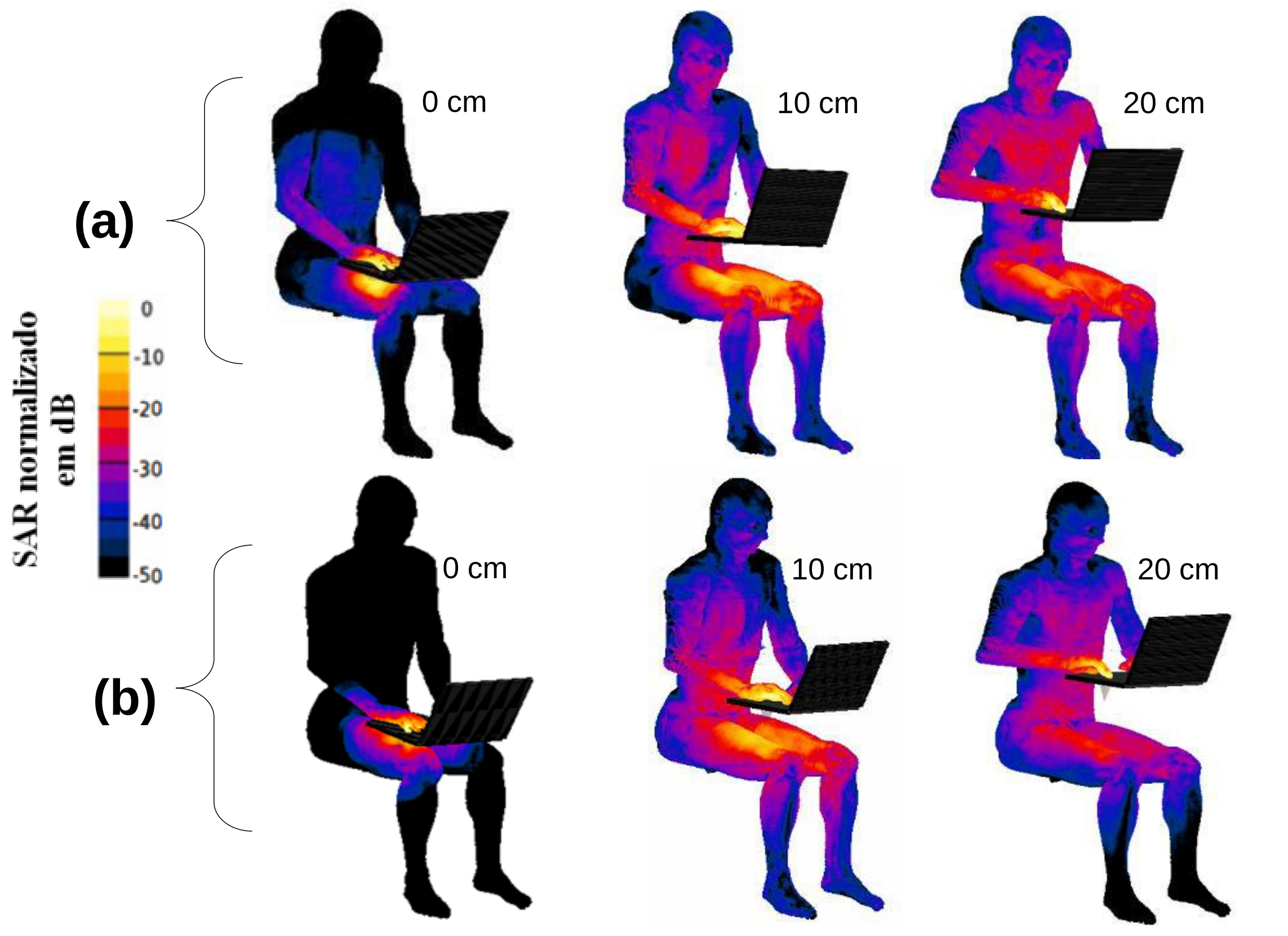


Fig. 3 - SAR distribution for situation ‘2’ with three distances between laptop and chest (22, 32, 42 cm respectively) for: (a) dipole and (b) PIFA.

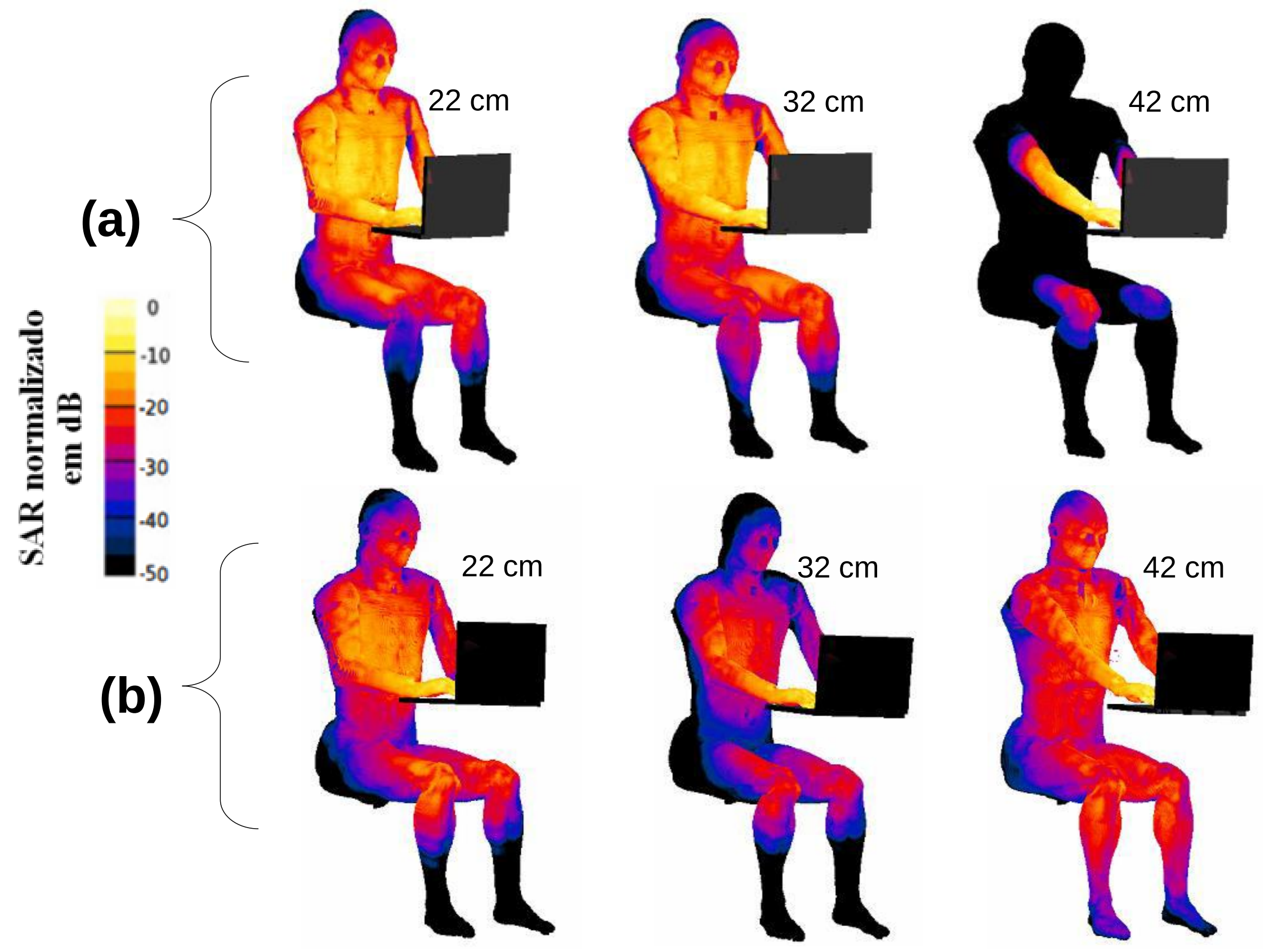


Table 1. The simulated psSAR values (W/Kg) in situation ‘1’

Antenna and distance	*psSAR 1g*	*psSAR 10g*
PIFA on the lap	**1,40**	**0,67**
PIFA 10 cm from the lap	0,56	0,36
PIFA 20 cm from the lap	1,01	0,55
Dipole on the lap	**3,02**	**1,36**
Dipole 10 cm from the lap	0,30	0,20
Dipole 20 cm from the lap	0,31	0,20

Table 2. The simulated psSAR values (W/Kg) in situation ‘2’

Antenna and position	*psSAR 1g*	*psSAR 10g*
PIFA 22 cm from the chest	0,030	0,017
PIFA 32 cm from the chest	0,036	0,018
PIFA 42 cm from the chest	0,026	0,016
Dipole 22 cm from the chest	0,018	0,010
Dipole 32 cm from the chest	0,017	0,008
Dipole 42 cm from the chest	0,016	0,009

Conclusions

It can be seen from the simulation that only in the situation in which the microcomputer uses a dipole and is on the lap the 1 gram psSAR is above the limit recommended in [2]. All other results are below the limits recommended in [2] for 1 gram of tissue, and in [3] and [4] for 10 gram of tissue.
It is very important to remark that the recommendations and the standards usually adopted in different countries only consider the health effects of short time exposure. But, these portable microcomputers may be used for long time very close to the user’s body. Therefore, the standards must consider the user’s health risks due to low level and long time exposure. Also, new antennas could be suggested in order to reduce the user’s EM absorption.

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