Identification of factors influencing the Whole Body Absorption Rate using statistical analysis

Aimad El Habachi, Emmanuelle Conil, Abdehamid Hadjem, Emmanuel Vazquez, Gilles Fleury, Joe Wiart

Identification of factors influencing the Whole Body Absorption Rate using statistical analysis

Aimad El habachi[1*], Emmanuelle Conil[1], Abdehamid Hadjem[1], Emmanuel Vazquez[2], Gilles Fleury[2], and Joe Wiart[1].

[1]France Telecom R&D, Issy les Moulineaux, France

[2]SUPELEC, Gif-sur-Yvette, France.

[*]Corresponding author's e-mail: aimad.elhabachi@orange-ftgroup.com

INTRODUCTION

To protect people from Electromagnetic Fields (EMF), ICNIRP has defined limits. The fundamental ones are the Basic Restrictions (BRs) [1]. The BRs determine the maximum values (averaged over the whole body and averaged over 10 grams of tissues) of Specific Absorption Rate (SAR). Since BRs can be complex to assess ICNIRP has also defined derived value: the reference levels (RLs). These RLs were established to guaranty the compliance to the BRs. Several studies with human model voxels (a.k.a. phantoms) show that even below the RLs, the WBSAR (Whole Body average SAR) may exceed the BRs due to the variability of human morphology [2].

In this paper we will identify the morphological factors influencing the WBSAR in the case of a frontal plane wave exposure at the frequency of 2100MHz in isolated conditions and vertical polar. The method is based on the construction of a model that makes it possible to estimate the statistical distribution of the WBSAR for a given human population.

MATERIALS AND METHODS

At the international levels, only few human voxel models exist. In our study, 12 models have been used (3 females, 7 males and 2 children). Other children phantoms were obtained using the morphing technique. Since the number of observations is very small, a purely statistical approach to estimate the distribution of the WBSAR is ruled out.

Our proposal is to build a model of the WBSAR as a function of a number of external factors (such as the Body Surface Area) and internal factors (such as the proportion of skin, muscles...). The parameters of the model are estimated by least squares. Statistical tests are used to determine the significance of the factors. Finally, we propose a technique to test the robustness of the model.

RESULTS

Recent publications [2, 3] highlighted the relationship between the WBSAR and external morphology. Several factors are found such as BSA/weight. The expression is as follow:

$$\hat{y}_{WBSAR} = \alpha X + \varepsilon \quad (1)$$

Where $\hat{y}_{WBSAR}$ is the estimated value of the WBSAR given by (1); α the unknown parameter of the models; X is the BSA/weight and ε is the error generated by (1).

The estimation of α using only the set of 12 phantoms generates an important error (30% in term of relative error). However the Student test [3] shows that α is very significant (different from 0). Nevertheless, the estimation of this parameter α using one family among the families of phantoms (where the family of phantoms contains an initial phantom and his morphed phantoms) achieves a very good estimation of the WBSAR (Figure 1). This parameter α is almost constant for each family. This leads us to conceive that α depends mainly on the internal morphology which is substantially the same for an adult and his morphed phantoms.

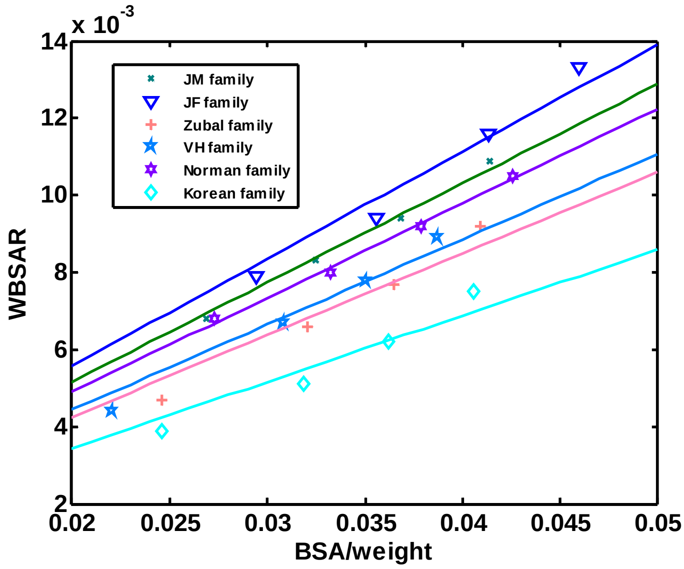

Figure 1: Relationship between BSA/weight and WBSAR at 2100MHz for the families of phantoms.

To test that α depends on the internal morphology. We have established this expression:

$$\hat{\alpha}(x_S, x_M, x_F, x_B) = \xi_1 + \xi_2(2x_S + x_M + x_F + \frac{3}{5}x_B) + \nu \qquad (2)$$

Where $\hat{\alpha}$ is the estimation of α, x_S the proportion of skin, x_M the proportion of muscle, x_F proportion of fat and x_B proportion of bones, ξ_1 and ξ_2 the parameters of (2) and ν is the errors generated by (2). In addition, the constant of multiplication affected to each of the internal factors have been established empirically from observations made on different models. The Student's test shows that the parameters ξ_1 and ξ_2 are very significant. Moreover, the coefficient of determination is equal to 0.89.

To study the stability of ξ_1 and ξ_2, we propose to estimate them with all the combination of 9 phantoms instead of 12. The parameters are relatively robust (only 5% of variability).

CONCLUSIONS

The aim of this study is to establish a simplified relationship Whole body average SAR in term of morphology. It also shows that the internal morphological factors are important in predicting WBSAR but it is more difficult to obtain statistical data of these factors.

The objective carried on is to build a statistical law for the parameter α taking into account the set of phantoms and our knowledge of the physical phenomena of wave absorption by the tissue to find the maximum WBSAR for a population.

REFERENCES

[1] ICNIRP 1998 Guidelines for Limiting Exposure to Time Varying Electric Magnetic and Electromagnetic Field (up to 300 GHz). Radiation Protection Health Physics, Volume 74, Number 4:494-522.

[2] Conil. E, Hadjem. A, Lacroux. F, Wong. MF and Wiart J 2008 Variability analysis of SAR from 20MHz to 2.4GHz for different adult and child models using FDTD Phys. *Med. Biol*. **53** 1511-1525.

[3] Hirata A, Nagaya Y, Fujiwara O, 2007 " Correlation between Absorption Cross Section and Body Surface Area of Human for Far-Field Exposureat GHz Bands".

[4] Saporta G Probabilités, analyse de données et statistiques, EDITIONS TECHNIP, January 1990.