NUMERICAL DOSIMETRY OF WHOLE-BODY HUMAN MODELS EXPOSED TO VHF ELECTROMAGNETIC WAVES

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1 Introduction

The numerical dosimetry using voxel human models is indispensable for investigation of the various electromagnetic exposure conditions. Many human head models have been developed in order to calculate SAR in a human head exposed to near-field of a cellular telephone. However, the human head models are not always appropriate to investigate near-field exposure by wearable wireless mobile devices or far-field exposure by broadcast towers. In the case of the far-field exposure in VHF band, especially, the whole-body models are necessary to estimate the whole-body SAR distribution because the whole-body resonance could occur in this frequency region.

The whole-body resonance is strongly dependent on the human-body size[1]. In most previous studies, however, the detail characteristics of the whole-body resonance were investigated only for adult male. Therefore, we developed adult male and female and child whole-body human models with various posture and estimated the SAR and induced current in their models. In this paper, the preliminary investigation using these whole-body human models is presented.

2 Method and Models

We used some whole-body human models; European-American adult male whole-body human model, Japanese adult male and female and child whole-body human models. The European-American model is based on the adult male human body database of the Visible Human Project and developed by US Air Force Laboratory (Fig. 1; [2]). The Japanese models with Japanese average size (Fig. 2) are smaller than the European-American model. Using a CAD software, the postures of the Japanese models can be changed as shown in Fig. 3. The voxel size of the human models is 5 mm. These models consisted of the homogeneous tissue (2/3-muscle) except the European-American model used for comparison between homogeneous and heterogeneous tissue structure. The electrical properties were refereed from Gabriel's report[3].

Finite-difference time-domain (FDTD) method was used to calculate the SAR and induced current in the human models. The 2nd approximations of Mur's absorbing boundary conditions were assumed in order to simulate radiation into free space. The perfectly electrical conductor (PEC) was also assumed at the ground plane.

3 Results and Discussion

SAR distributions in the vertical section in the human models at the resonant frequency of the adult male (38 MHz) are shown in Fig. 4. It is shown that the location of the peak SAR appears around the ankles in regardless of the inhomogeneity of the human model as well as on the difference of the height of the model.

Figure 1: European-American adult male whole-body human model developed by US Air Force Laboratory [2]. The height is 180 cm.

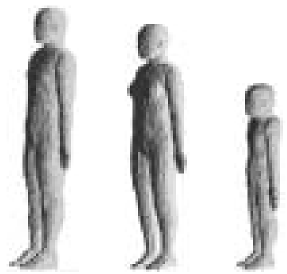

Figure 2: Japanese adult male and female and child (7 years old) model. Their heights are 171, 159, 121 cm, respectively.

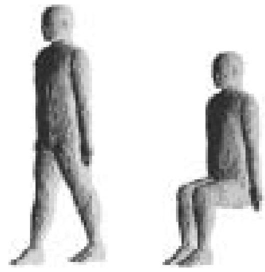

Figure 3: Japanese adult male model (walking and sitting).

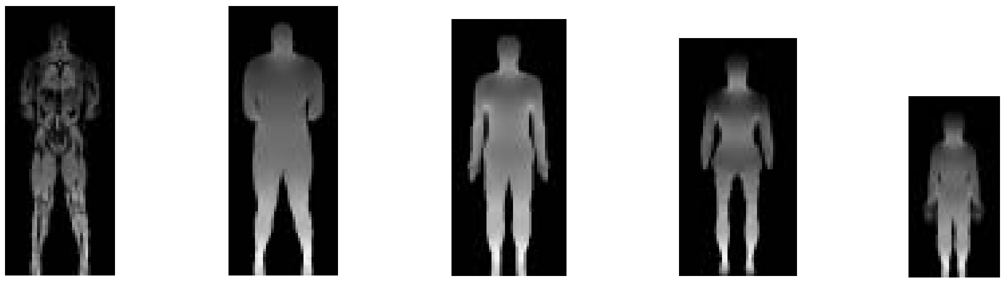

Figure 4: SAR distributions in the vertical section of the whole-body human models (inhomogeneous-tissue European-American (EA) adult male, homogeneous-tissue EA adult male, homogeneouse-tissue Japanese adult male, female, and child) exposed to E-polarized TEM wave at 38 MHz. The SAR is normalized by the maximum value in the section and shown in logarithmic scale.

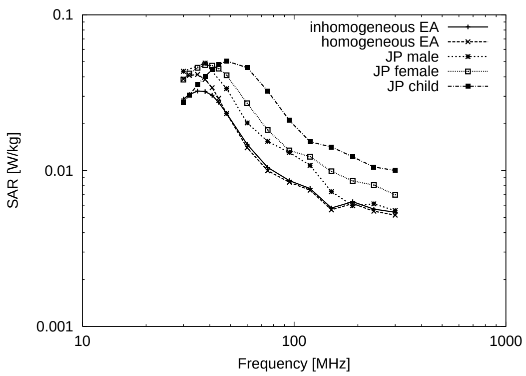

Figure 5: Frequency charcteristics of the whole-body averaged SAR of the human models exposed to E-polarized TEM wave (1 W/m^2).

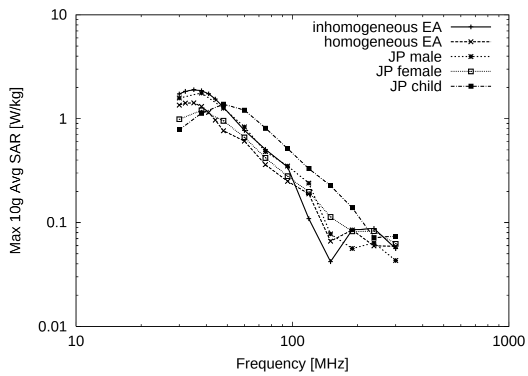

Figure 6: Frequency charcteristics of the maximum local SAR (10-g average) of the human models exposed to E-polarized TEM wave (1 W/m^2).

The frequency characteristics of whole-body averaged SAR and the maximum local SAR are shown in Figs. 5 and 6, respectively. The resonant frequency of the whole-body averaged SAR depends on the height of the models. It is also shown that the peak values of the whole-body averaged SAR of the homogeneous models are nearly equal to each others although those are higher than that of the inhomogeneous European-American model. In the case of the maximum local SAR, however, such consistent trend is not found.

The induced current distributions are also shown in Fig. 7. It is shown that the frequency character-

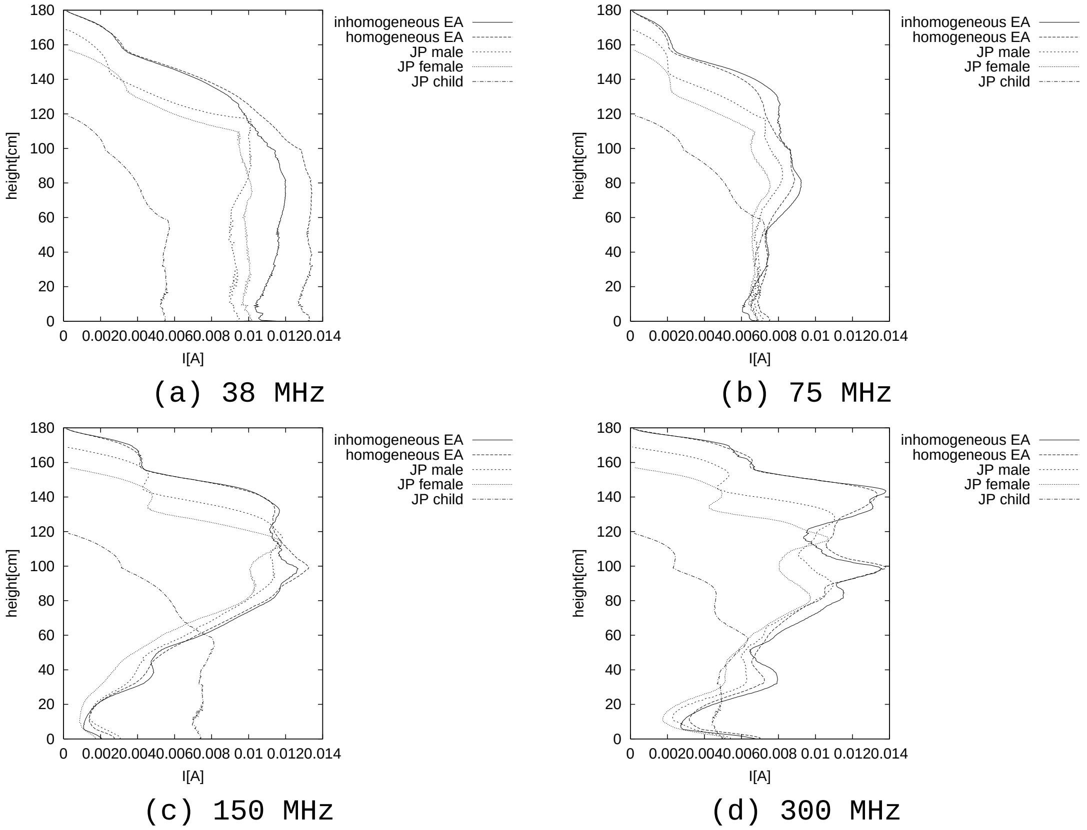

Figure 7: Current distribution of the human models exposed to E-polarized TEM wave (1 W/m^2).

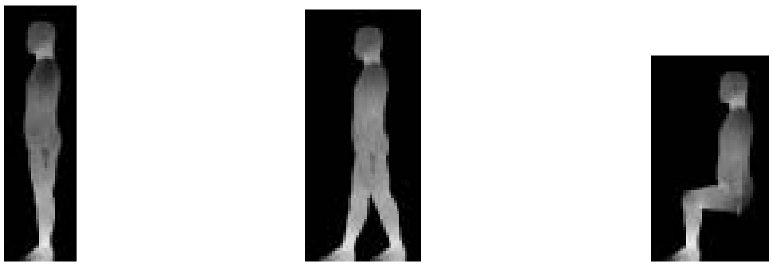

Figure 8: SAR distributions on the surface of the whole-body human models exposed to E-polarized TEM wave at 38 MHz.

istics of the current distribution is clearly different between the adult and child.

The SAR distributions and the frequency characteristics of the whole-body averaged SAR and the maximum local SARs of the Japanese adult male models as shown in Fig. 3 were also calculated (Figs. 8, 9 and 10). It is shown that the region where the peak SAR appears is always around the ankles in regardless of the difference of the posture. It is also shown that the frequency characteristics of the whole-body averaged SAR and the maximum local SAR of the walking model agree well with the standing model but not those of the sitting model.

At the presentation, we will discuss detail characteristics of the SAR and induced current of the whole-body human model with various height (age) and posture.

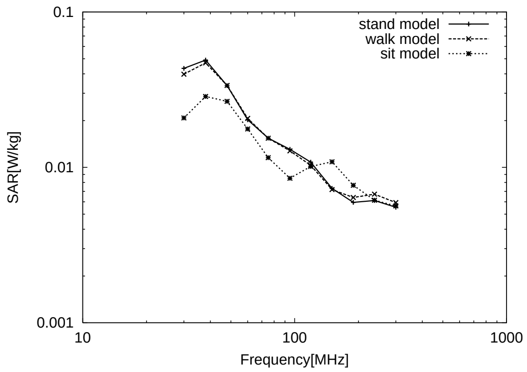

Figure 9: Frequency charcteristics of the whole-body averaged SAR of the human models exposed to E-polarized TEM wave (1 W/m^2).

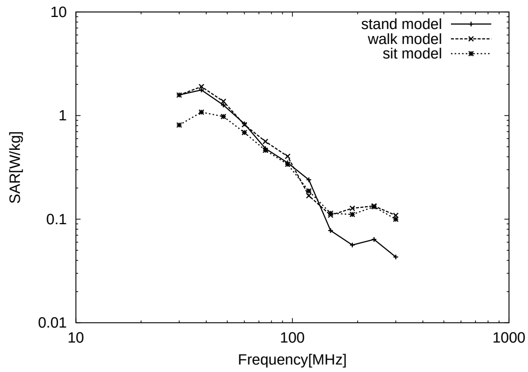

Figure 10: Frequency charcteristics of the maximum local SAR (10-g average) of the human models exposed to E-polarized TEM wave (1 W/m^2).

Acknowledgement

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