VK-phantom male with 583 structures and female with 459 structures, based on the sectioned images of a male and a female, for computational dosimetry

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ABSTRACT

The anatomical structures in most phantoms are classified according to tissue properties rather than according to their detailed structures, because the tissue properties, not the detailed structures, are what is considered important. However, if a phantom does not have detailed structures, the phantom will be unreliable because different tissues can be regarded as the same. Thus, we produced the Visible Korean (VK) -phantoms with detailed structures (male, 583 structures; female, 459 structures) based on segmented images of the whole male body (interval, 1.0 mm; pixel size, 1.0 mm²) and the whole female body (interval, 1.0 mm; pixel size, 1.0 mm²), using house-developed software to analyze the text string and voxel information for each of the structures. The density of each structure in the VK-phantom was calculated based on Virtual Population and a publication of the International Commission on Radiological Protection. In the future, we will standardize the size of each structure in the VK-phantoms. If the VK-phantoms are standardized and the mass density of each structure is precisely known, researchers will be able to measure the exact absorption rate of electromagnetic radiation in specific organs and tissues of the whole body.

Keywords: electromagnetic radiation; radiometry; phantoms imaging; Visible Human Project

INTRODUCTION

To investigate the human body’s absorption of electromagnetic ionizing and non-ionizing radiation generated by electronic and medical devices, various computational dosimetry phantoms of humans have been developed based on magnetic resonance imaging (MRI), computed tomography (CT) [1, 2], sectioned images [3–6] and hybrid images [7, 8].

However, in most phantoms, detailed structures of the entire body cannot be shown due to the limited resolution of CT or MRI. Even the International Commission on Radiological Protection (ICRP) and Virtual Family reference phantoms (which were generated from various source images, including high-resolution sectioned images and hybrid images) contain only 137 structures and 103 structures for the whole human body, respectively [1, 9–11]. The reasons that detailed structures could not be shown in the phantoms were as follows. First, the structures in the source images were not segmented in detail, even though detailed structures could be observed in the source images. Second, the voxel size of the source images was too large (<2 mm³), despite the source images with very small voxel size (<0.2 mm³). Third, an increase in the number of structures in the phantom resulted in a large file size, meaning that the phantom could not be examined on a personal computer. In particular, in the case of phantoms based on polygonal surface models, a huge file and an enormous number of polygonal surfaces were made, and consequently, the phantom could not be managed by researchers or workers for a commercial test.

Furthermore, in Virtual Population [11], which contains the most well-known phantom data, phantom structures are classified only according to the tissue features based on the Gabriel List [12], though this can lead to erroneous measurement results because tissues with identical features can be interpreted as different, and
tissues with different features can be interpreted as being identical. For example, in the ICRP reference phantom, the densities of the esophagus, spinal cord, and trachea are identical [9, 13, 14], but their tissue features differ: the esophagus is composed of muscle tissue, the spinal cord is composed of nerve tissue, and the trachea is composed of cartilaginous tissue. In the case of Virtual Population, the density of the cerebellum (nerve tissue), esophagus (muscle tissue) and urinary bladder (connective tissue) are considered to be identical [1], but their tissue features differ.

The aim of the current study was to present the Visible Korean (VK) phantom with 583 (male) and 459 (female) structures with sufficient segmentation such that radiation energy absorption can be evaluated. Another aim was to develop methods for converting large-sized segmentation data into a phantom. To achieve these goals, phantoms of a precise shape and detailed structures were manufactured based on high-resolution, real-color sectioned images of the VK.

**MATERIALS AND METHODS**

In previous studies, 8590 sectioned images of a whole male body (intervals, 0.2 mm; pixel size, 0.2 mm²; resolution, 3040 × 2008; color depth, 24 bit color; file format, TIF) [15] and 4116 sectioned images of a whole female body (intervals, 0.2 mm (head to pelvis) or 1.0 mm (lower limb); pixel size, 0.1 mm²; resolution, 5616 × 3744; color depth, 48 bit color; file format, BMP) [16] were produced. In the male and female images, real color and high-resolution structures could be observed in the cross-sectional plane (Fig. 1a and c; Table 1).

We used the data of previous studies, which were for segmented images with 583 structures in the male body (resolution, 2468 × 1407; interval, 1 mm; pixel size, 0.2 mm²) (Table 2) [17] and segmented images with 171 structures in the female body (resolution, 5610 × 2300; interval, 1 mm; pixel size, 0.1 mm²) (Table 3) [16] based on the sectioned images of a male and female. In this study, to make a female phantom containing more detailed structures, additional segmentation was performed as follows. First, to segment the sectioned images of the female, the selected structures were outlined using the Quick Selection Tool or the Magnetic Lasso Tool in Photoshop CC 2015 (Adobe Systems, Inc., San Jose, CA, USA). The inner areas of the outlines were filled with specific RGB colors and saved as the segmented images (Fig. 1b and d; Table 1) [18, 19]. Consequently, we also generated segmented images containing an additional 288 structures from the female sectioned images to generate a total of 459 structures (Table 3).

The pixel size of the segmented images (both male and female) was increased from 0.2 mm² (male) or 0.1 mm² (female) to 1 mm² (resolution of male, 493 × 281; resolution of female, 562 × 230). Consequently, the voxels of the segmented images became 1-mm³ cubes, and the file size of the images decreased from 16.5 GB to 675 MB for males and from 59.2 GB to 608 MB for females (Table 1).

To produce a phantom of TXT format, house-developed software (VK-phantom.jar) was designed using Java language on Eclipse Java IDE for web developers, Luna Service Release 1 (4.4.1). In the software, all voxel information (pixels, intervals, and RGB colors) of each structure in the segmented images could be converted into numerical data in TXT format.

After identification (ID) numbers were serially assigned to all segmented structures in the segmented images, the ID numbers and RGB values of segmented structures were recorded in data.xlsx (Fig. 2a). The data.xlsx was converted into data.txt. When the segmented images of male and data.txt were opened on VK-phantom.jar, the x, y and z coordinates and RGB values were stored temporarily on a personal computer, and the RGB values in the segmented...

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**Fig. 1.** Sectioned images and segmented images of a male and female for making VK-phantoms. (a) In the sectioned images of the male whole body, (b) segmented images of 583 structures were made. (c) In the sectioned images of the female whole body, (d) segmented images of 459 structures were made.
images were converted into ID numbers (Fig. 2b). Finally, the x, y and z coordinates and ID numbers were saved as the VK-phantom male in TXT format. Voxel information for the male VK-phantom, including the x, y and z coordinates and ID number, are presented in a row (Fig. 2c). The VK-phantom female (in TXT format) was generated from the segmented images of the female using the same methods.

To analyze the text string in the VK-phantom of TXT format, house-developed software (String_analysis.exe) was developed using C# language on Eclipse Java IDE for web developers, Luna Service Release 1 (4.4.1). Voxel information for the VK-phantom, including ID number and x, y and z coordinates, is presented in a row; consequently, the number of rows with identical ID numbers represents the voxel number of a structure (Fig. 2c). After the VK-phantom male and female were opened on String_analysis.exe, the number of rows with identical ID numbers in the phantom was written in the window (Fig. 2d).

Structures of the VK-phantoms were rearranged according to the structure list in Virtual Population. The voxel number of the rearranged structures in the VK-phantoms was multiplied by the structure density (g/mm³) in Virtual Population [1, 4, 5, 12] to measure the weight of each structure (Tables 2 and 3). However, the densities of some rearranged structures did not follow those of Virtual Population (marked with superscripts ‘a’ and ‘b’ in Tables 2 and 3) because the densities reported in Virtual Population were not accurate. For example, in Virtual Population, the density of the cerebellum (1040 kg/m³) is identical to that of the esophagus and urinary bladder.

RESULTS

From the segmented images based on a previous study [17], reduced segmented images were prepared (intervals, 1.0 mm; pixel size, 1.0 mm²), in which the 583 structures could be sorted by color (Fig. 1b; Table 1). The VK-phantom male was produced based on the reduced segmented images on which the x, y and z coordinates and structure ID numbers were marked (Fig. 2c). In the VK-phantom male, fat was the heaviest structure (8231 g), followed by the lung (3641 g). The lightest structure was the sinoatrial nodal branch (0.01 g). The real weights of the phantom’s actual person and the total weight of the phantom were 55 kg [15] and 58 kg, respectively (Table 2).

Similar to the VK-phantom male, the VK-phantom female was produced from the segmented images of the female, with 459 structures (Fig. 1d; Table 1). In the VK-phantom female, fat was the heaviest structure (29 666 g), followed by the skin (1714 g), femur (1684 g) and cranium without the mandible (10849 g). The female cranium was heavier than that of the male because the cranium in the phantom was an object, unlike several objects of male cranium (Table 1). The lightest structure was the posterior commissure (0.01 g). The weights of the actual woman and total weight of the phantom were 52 kg [16] and 55 kg, respectively (Table 3).

All structures in the VK-phantom male and female were rearranged according to Virtual Population [1, 11, 20] and sorted mainly by tissue features. In the rearranged VK-phantom male, the muscles (22 780 g) and bones (13 317 g) were heavier than fat (8231 g) in the VK-phantom with 583 structures. In the case of the female, fat was the heaviest structure. Consequently, the VK-phantom female was obese. In both the male and female VK-phantoms, the eye (cornea) was the lightest structure (Table 4).

Furthermore, the rearranged VK-phantoms were compared with the High-Definition Reference Korean Man (HDRK), Virtual Family and ICRP phantoms [1, 4, 5]. The weights of most structures in the four phantoms were similar. However, a few structures (skin, blood, fat and spleen) were very different. In particular, the skins of VK-phantom male and HDRK man were almost twice the weight, although the source images of the VK-phantom male and HDRK man were identical [15]. In the case of the spleen, the VK-phantom’s actual person had splenomegaly from leukemia. Therefore, the VK-phantom male’s spleen was very heavy (1110 g) compared with that of other phantoms, but the HDRK man’s spleen was light (177 g), even though the source images of the two phantoms were almost identical.

| Table 1. Features of the segmented images and male and female VK-phantoms |
|---------------------------------------------------------------|
| Sex   | Images             | Number of structures | Number of data | Intervals (mm) | Pixel or voxel size | Color depth (bit color) | Total file size (GB) | File format |
|-------|--------------------|----------------------|----------------|----------------|--------------------|------------------------|----------------------|-------------|
| Male  | Sectioned images   | 8500                 | 0.2            | 0.2 mm² (pixel) | 24                 | 82.5                   | TIFF                 |
|       | Segmented images   | 581                  | 1700           | 1.0            | 0.2 mm² (pixel)    | 24                    | 16.5                 | TIFF        |
|       | VK-phantom         | 581                  | 1              | 1.0 mm³ (voxel) | 1.9               | 1.0                    | 16.5                 | TXT         |
| Female| Sectioned images   | 4116                 | 1              | 0.2 or 1.0     | 0.1 mm² (pixel)    | 48                    | 580.0                | TIFF        |
|       | Segmented images   | 171                  | 1643           | 1.0            | 0.1 mm² (pixel)    | 24                    | 59.2                 | TIFF        |
|       | Segmented images   | 287                  | 1              | 0.1 mm² (pixel) | 24               | 59.2                   | 16.5                 | TIFF        |
|       | VK-phantom         | 458                  | 1              | 1.0 mm³ (voxel) | 0.9              | 1                      | 16.5                 | TXT         |

*Result of a previous study.

¹Upper body from the head to perineum.

²Lower limb from below the perineum to the sole.
Table 2. A listing of 583 body structures of the VK-phantom male, and the mass of each structure according to material densities in Virtual Population (2017)

| Structures                                           | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|------------------------------------------------------|----------------------|---------------------------------|------------------------------------------------|--------------------|---------------------------------|
| Abductor digiti minimi m. (right)                    | 17213                | Muscle                          | Muscle                                         | 1090               | 18.76                           |
| Abductor digiti minimi m. (left)                     | 13969                | Muscle                          | Muscle                                         | 1090               | 15.23                           |
| Abductor hallucis m.                                  | 35928                | Muscle                          | Muscle                                         | 1090               | 39.16                           |
| Abductor pollicis brevis m.                           | 13866                | Muscle                          | Muscle                                         | 1090               | 15.11                           |
| Abductor pollicis longus m.                           | 45197                | Muscle                          | Muscle                                         | 1090               | 49.26                           |
| Accessory hemi-azygos v.                              | 1338                 | Blood                           | Blood                                          | 1050               | 1.40                            |
| Acetabular labrum                                     | 577                  | Tendon/Ligament                 | Tendon/Ligament                                 | 1142               | 0.66                            |
| Adductor brevis m.                                    | 182623               | Muscle                          | Muscle                                         | 1090               | 199.06                          |
| Adductor hallucis m. oblique head                     | 24135                | Muscle                          | Muscle                                         | 1090               | 26.31                           |
| Adductor hallucis m. transverse head                  | 3181                 | Muscle                          | Muscle                                         | 1090               | 3.47                            |
| Adductor longus m.                                    | 269631               | Muscle                          | Muscle                                         | 1090               | 293.90                          |
| Adductor magnus m.                                    | 683101               | Muscle                          | Muscle                                         | 1090               | 744.58                          |
| Adductor pollicis m.                                  | 6724                 | Muscle                          | Muscle                                         | 1090               | 7.33                            |
| Adenohypophysis                                       | 604                  | Hypophysis                       | Hypophysis                                     | 1053               | 0.64                            |
| Air                                                   | 0                    | Air                             | Air                                            | 1                  | 0.00                            |
| Amygdaloid nucleus                                    | 415                  | Brain (gray matter)             | Brain (gray matter)                             | 1045               | 0.43                            |
| Anal canal                                            | 879                  | Large intestine                 | Large intestine                                | 1088               | 0.96                            |
| Anconeus m.                                           | 2748                 | Muscle                          | Muscle                                         | 1090               | 3.00                            |
| Anterior basal segmental bronchus                     | 589                  | Bronchi                         | Bronchi                                        | 1102               | 0.65                            |
| Anterior cruciate ligament                            | 798                  | Tendon/Ligament                 | Tendon/Ligament                                 | 1142               | 0.91                            |
| Anterior interventricular branch                      | 981                  | Blood                           | Blood                                          | 1050               | 1.03                            |
| Anterior longitudinal ligament                        | 9646                 | Tendon/Ligament                 | Tendon/Ligament                                 | 1142               | 11.02                           |
| Anterior ramus of fifth lumbar n.                     | 2758                 | Nerve                           | Nerve                                          | 1075               | 2.96                            |
| Anterior ramus of first lumbar n.                     | 165                  | Nerve                           | Nerve                                          | 1075               | 0.18                            |
| Anterior ramus of first sacral n.                     | 2713                 | Nerve                           | Nerve                                          | 1075               | 2.92                            |
| Anterior ramus of fourth lumbar n.                    | 906                  | Nerve                           | Nerve                                          | 1075               | 0.97                            |
| Anterior ramus of second lumbar n.                    | 311                  | Nerve                           | Nerve                                          | 1075               | 0.33                            |
| Anterior ramus of second sacral n.                    | 2277                 | Nerve                           | Nerve                                          | 1075               | 2.45                            |
| Anterior ramus of third lumbar n.                     | 507                  | Nerve                           | Nerve                                          | 1075               | 0.55                            |
| Anterior ramus of third sacral n.                     | 642                  | Nerve                           | Nerve                                          | 1075               | 0.69                            |
| Anterior rectus capitis m.                            | 1670                 | Muscle                          | Muscle                                         | 1090               | 1.82                            |

Continued
Table 2. Continued

| Structures                        | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|-----------------------------------|----------------------|---------------------------------|-----------------------------------------------|-------------------|---------------------------------|
| Anterior root of fifth lumbar n.  | 235                  | Nerve                           |                                               | 1075              | 0.25                            |
| Anterior root of first lumbar n.  | 52                   | Nerve                           |                                               | 1075              | 0.06                            |
| Anterior root of first sacral n.  | 585                  | Nerve                           |                                               | 1075              | 0.63                            |
| Anterior root of fourth lumbar n.| 295                  | Nerve                           |                                               | 1075              | 0.32                            |
| Anterior root of second lumbar n.| 48                   | Nerve                           |                                               | 1075              | 0.05                            |
| Anterior root of second sacral n.| 464                  | Nerve                           |                                               | 1075              | 0.50                            |
| Anterior root of third lumbar n.  | 105                  | Nerve                           |                                               | 1075              | 0.11                            |
| Anterior root of third sacral n.  | 100                  | Nerve                           |                                               | 1075              | 0.11                            |
| Anterior scalenus m.             | 15727                | Muscle                          |                                               | 1090              | 17.14                           |
| Anterior segmental bronchus       | 5526                 | Bronchi                         |                                               | 1102              | 6.09                            |
| Anterior serratus m.              | 349220               | Muscle                          |                                               | 1090              | 380.65                          |
| Anterior tibial a.                | 371                  | Blood                           |                                               | 1050              | 0.39                            |
| Anterior tibialis m.              | 236332               | Muscle                          |                                               | 1090              | 257.60                          |
| Aortic valve                      | 847                  | Cartilage                       |                                               | 1100              | 0.93                            |
| Apical segmental bronchus         | 546                  | Bronchi                         |                                               | 1102              | 0.60                            |
| Apicoposterior segmental bronchus | 936                  | Bronchi                         |                                               | 1102              | 1.03                            |
| Appendix                          | 22725                | Large intestine                 |                                               | 1088              | 24.72                           |
| Arch of aorta                     | 13349                | Blood                           |                                               | 1050              | 14.02                           |
| Articularis genus m.              | 2605                 | Muscle                          |                                               | 1090              | 2.84                            |
| Ascending aorta                   | 19325                | Blood                           |                                               | 1050              | 20.29                           |
| Ascending colon                   | 46238                | Large intestine                 |                                               | 1088              | 50.31                           |
| Atrioventricular nodal branch     | 37                   | Blood                           |                                               | 1050              | 0.04                            |
| Auditory tube                     | 66                   | Cartilage                       |                                               | 1100              | 0.07                            |
| Axillary a.                       | 2542                 | Blood                           |                                               | 1050              | 2.67                            |
| Axillary v.                       | 12062                | Blood                           |                                               | 1050              | 12.67                           |
| Azygous v.                        | 6052                 | Blood                           |                                               | 1050              | 6.35                            |
| Basilar a.                        | 80                   | Blood                           |                                               | 1050              | 0.08                            |
| Basilic v.                        | 1891                 | Blood                           |                                               | 1050              | 1.99                            |
| Biceps brachii m.                 | 191270               | Muscle                          |                                               | 1090              | 208.48                          |
| Biceps femoris m.                 | 385341               | Muscle                          |                                               | 1090              | 420.02                          |
| Brachial a.                       | 3369                 | Blood                           |                                               | 1050              | 3.54                            |

Continued
| Structures                        | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|----------------------------------|----------------------|----------------------------------|-----------------------------------------------|--------------------|--------------------------------|
| Brachial plexus                  | 3267                 | Nerve                            |                                               | 1075               | 3.51                           |
| Brachial v.                      | 14874                | Blood                            |                                               | 1050               | 15.62                          |
| Brachialis m.                    | 232229               | Muscle                           |                                               | 1090               | 253.13                         |
| Brachiocephalic trunk            | 4631                 | Blood                            |                                               | 1050               | 4.86                           |
| Brachiocephalic vein             | 13457                | Blood                            |                                               | 1050               | 14.13                          |
| Brachioradialis m.               | 98728                | Muscle                           |                                               | 1090               | 107.61                         |
| Brain (Lateral ventricle)        | 9984                 | Cerebrospinal fluid              |                                               | 1007               | 10.05                          |
| Brainstem                        | 30016                | Brain                            |                                               | 1046               | 31.40                          |
| Buccinator m.                    | 11795                | Muscle                           |                                               | 1090               | 12.86                          |
| Bulbospongiosus m.               | 5716                 | Muscle                           |                                               | 1090               | 6.23                           |
| Calcaneum                        | 129770               | Bone (cortical)                  |                                               | 1908               | 247.60                         |
| Capitate                         | 8381                 | Bone (cortical)                  |                                               | 1908               | 15.99                          |
| Caudate nucleus                  | 14997                | Brain (gray matter)              |                                               | 1045               | 15.67                          |
| Cecum                            | 42833                | Large intestine                  |                                               | 1088               | 46.60                          |
| Celiac trunk                     | 323                  | Blood                            |                                               | 1050               | 0.34                           |
| Cephalic v.                      | 6529                 | Blood                            |                                               | 1050               | 6.86                           |
| Cerebellum+a                     | 167429               | Cerebellum                       | Brain                                         | 1046               | 175.13                         |
| Cervical vertebra (fifth)        | 15907                | Vertebrae                        |                                               | 1908               | 30.35                          |
| Cervical vertebra (first)        | 24574                | Vertebrae                        |                                               | 1908               | 46.89                          |
| Cervical vertebra (fourth)       | 15993                | Vertebrae                        |                                               | 1908               | 30.51                          |
| Cervical vertebra (second)       | 21579                | Vertebrae                        |                                               | 1908               | 41.17                          |
| Cervical vertebra (seventh)      | 21910                | Vertebrae                        |                                               | 1908               | 41.80                          |
| Cervical vertebra (sixth)        | 16945                | Vertebrae                        |                                               | 1908               | 32.33                          |
| Cervical vertebra (third)        | 16249                | Vertebrae                        |                                               | 1908               | 31.00                          |
| Circumflex branch                | 391                  | Blood                            |                                               | 1050               | 0.41                           |
| Claustrum                        | 2879                 | Brain (gray matter)              |                                               | 1045               | 3.01                           |
| Clavicle                         | 70883                | Bone (cortical)                  |                                               | 1908               | 135.24                         |
| Coccygeus m.                     | 4182                 | Muscle                           |                                               | 1090               | 4.56                           |
| Coccyx                           | 6351                 | Bone (cortical)                  |                                               | 1908               | 12.12                          |
| Common bile ductb                | 1247                 | Bile                             |                                               | 928                | 1.16                           |
| Common carotid a.                | 7529                 | Blood                            |                                               | 1050               | 7.91                           |
Table 2. Continued

| Structures                     | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|-------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|----------------------------------|
| Common fibular n.             | 2436                 | Nerve                            |                                               | 1075                | 2.62                             |
| Common hepatic a.             | 186                  | Blood                            |                                               | 1050                | 0.20                             |
| Common hepatic ductb          | 1227                 | Urinary bladder wall            |                                               | 1086                | 1.33                             |
| Common iliac a.               | 2257                 | Blood                            |                                               | 1050                | 2.37                             |
| Common iliac v.               | 3047                 | Blood                            |                                               | 1050                | 3.20                             |
| Confluence of sinuses         | 1069                 | Blood                            |                                               | 1050                | 1.12                             |
| Constrictor m.                | 17658                | Muscle                           |                                               | 1090                | 19.25                            |
| Coracobrachialis m.           | 31862                | Muscle                           |                                               | 1090                | 34.73                            |
| Coracobrachialis m.           | 30152                | Muscle                           |                                               | 1090                | 32.87                            |
| Coronary sinus                | 3877                 | Blood                            |                                               | 1050                | 4.07                             |
| Corpus cavernosa penisb       | 8292                 | Blood                            |                                               | 1050                | 8.71                             |
| Corpus spongiosum penisb      | 7267                 | Blood                            |                                               | 1050                | 7.63                             |
| Cranium without mandible      | 97031                | Skull cortical                   |                                               | 1908                | 185.14                           |
| Cricothyroid m.               | 1629                 | Muscle                           |                                               | 1090                | 1.78                             |
| Crista galli                  | 274                  | Skull cortical                   |                                               | 1908                | 0.52                             |
| Cuboid                        | 26192                | Bone (cortical)                  |                                               | 1908                | 49.97                            |
| Cystic a.                     | 18                   | Blood                            |                                               | 1050                | 0.02                             |
| Cystic ductb                  | 2180                 | Bile                             |                                               | 928                 | 2.37                             |
| Deep brachial a.              | 429                  | Blood                            |                                               | 1050                | 0.45                             |
| Deep femoral a.               | 1074                 | Blood                            |                                               | 1050                | 1.13                             |
| Deep fibular n.               | 1300                 | Nerve                            |                                               | 1075                | 1.40                             |
| Deep transverse perineal m.   | 3895                 | Muscle                           |                                               | 1090                | 4.25                             |
| Deltoid m.                    | 585531               | Muscle                           |                                               | 1090                | 638.23                           |
| Descending aorta              | 56011                | Blood                            |                                               | 1050                | 58.81                            |
| Descending colon              | 128518               | Large intestine                  |                                               | 1088                | 139.83                           |
| Diaphragm                     | 305421               | Diaphragm                        |                                               | 1090                | 332.91                           |
| Digastric m.                  | 13708                | Muscle                           |                                               | 1090                | 14.94                            |
| Distal phalanx (fifth)         | 1009                 | Bone (cortical)                  |                                               | 1908                | 1.93                             |
| Distal phalanx (fifth)         | 777                  | Bone (cortical)                  |                                               | 1908                | 1.48                             |
| Distal phalanx (first)         | 4406                 | Bone (cortical)                  |                                               | 1908                | 8.41                             |
| Distal phalanx (first)         | 4051                 | Bone (cortical)                  |                                               | 1908                | 7.73                             |

Continued
Table 2. Continued

| Structures                      | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|--------------------------------|----------------------|---------------------------------|-------------------------------------------------|---------------------|---------------------------------|
| Distal phalanx (fourth)        | 1388                 | Bone (cortical)                 |                                                 | 1908                | 2.65                            |
| Distal phalanx (fourth)        | 1055                 | Bone (cortical)                 |                                                 | 1908                | 2.01                            |
| Distal phalanx (second)        | 1578                 | Bone (cortical)                 |                                                 | 1908                | 3.01                            |
| Distal phalanx (second)        | 846                  | Bone (cortical)                 |                                                 | 1908                | 1.61                            |
| Distal phalanx (third)         | 1631                 | Bone (cortical)                 |                                                 | 1908                | 3.11                            |
| Distal phalanx (third)         | 835                  | Bone (cortical)                 |                                                 | 1908                | 1.59                            |
| Dorsal interossei m.           | 46077                | Muscle                          |                                                 | 1090                | 50.22                           |
| Ductus deferens                | 2703                 | Ductus deferens                 | Urinary bladder wall                            | 1086                | 2.94                            |
| Duodenum                       | 12398                | Small intestine                 | Urinary bladder wall                            | 1086                | 13.46                           |
| Ejaculatory duct               | 19                   |                                 | Urinary bladder wall                            | 1086                | 0.02                            |
| Epididymis                     | 9979                 | Epididymis                      |                                                 | 1082                | 10.80                           |
| Erector spinae m.              | 260222               | Muscle                          |                                                 | 1090                | 283.64                          |
| Esophagus (luminal)            | 6418                 | Esophagus lumen                 |                                                 | 1                   | 0.01                            |
| Ethmoid bone                   | 64932                | Skull cortical                  |                                                 | 1908                | 123.89                          |
| Ethmoidal cells                | 2296                 | Air                             |                                                 | 1                   | 0.00                            |
| Extensor carpi radialis brevis m. | 31153            | Muscle                          |                                                 | 1090                | 33.96                           |
| Extensor carpi radialis longus m. | 95726            | Muscle                          |                                                 | 1090                | 104.34                          |
| Extensor carpi ulnaris m.      | 66797                | Muscle                          |                                                 | 1090                | 72.81                           |
| Extensor digiti minimi m.      | 15904                | Muscle                          |                                                 | 1090                | 17.34                           |
| Extensor digitorum brevis m.   | 22753                | Muscle                          |                                                 | 1090                | 24.80                           |
| Extensor digitorum longus m.   | 121812               | Muscle                          |                                                 | 1090                | 132.78                          |
| Extensor digitorum m.          | 78107                | Muscle                          |                                                 | 1090                | 85.14                           |
| Extensor hallucis longus m.    | 48025                | Muscle                          |                                                 | 1090                | 52.35                           |
| Extensor indicis m.            | 5921                 | Muscle                          |                                                 | 1090                | 6.45                            |
| Extensor indicis m.            | 5810                 | Muscle                          |                                                 | 1090                | 6.33                            |
| Extensor pollicis brevis m.    | 1441                 | Muscle                          |                                                 | 1090                | 1.57                            |
| Extensor pollicis longus m.    | 14067                | Muscle                          |                                                 | 1090                | 15.33                           |
| External acoustic meatus       | 2327                 | Bone (cortical)                 |                                                 | 1908                | 4.44                            |
| External anal sphincter m.     | 10627                | Muscle                          |                                                 | 1090                | 11.58                           |
| External carotid a.            | 549                  | Blood                           |                                                 | 1050                | 0.58                            |
| External iliac a.              | 2064                 | Blood                           |                                                 | 1050                | 2.17                            |

Continued
Table 2. Continued

| Structures                              | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|-----------------------------------------|----------------------|----------------------------------|-------------------------------------------------|---------------------|---------------------------------|
| External iliac v.                       | 6088                 | Blood                            |                                                 | 1050                | 6.39                            |
| External oblique abdominal m.           | 372614               | Muscle                           |                                                 | 1090                | 406.15                          |
| External urethral sphincter m.          | 485                  | Muscle                           |                                                 | 1090                | 0.53                            |
| Eye (choroid)                           | 1318                 | Blood                            |                                                 | 1050                | 1.38                            |
| Eye (cornea)                            | 16                   | Eye (cornea)                     |                                                 | 1051                | 0.02                            |
| Eye (lens)                              | 512                  | Eye (lens)                       |                                                 | 1076                | 0.55                            |
| Eye (sclera)                            | 1330                 | Eye (sclera)                     |                                                 | 1032                | 1.37                            |
| Eye (vitreous humor)                    | 15293                | Eye (vitreous humor)             |                                                 | 1005                | 15.37                           |
| Fat                                     | 8986675.5            | Fat                              |                                                 | 911                 | 8186.86                         |
| Femoral a.                              | 3634                 | Blood                            |                                                 | 1050                | 3.82                            |
| Femoral n.                              | 5419                 | Nerve                            |                                                 | 1075                | 5.83                            |
| Femoral v.                              | 12552                | Blood                            |                                                 | 1050                | 13.18                           |
| Femur                                   | 967336               | Bone (cortical)                  |                                                 | 1908                | 1845.68                         |
| Fibula                                  | 104947               | Bone (cortical)                  |                                                 | 1908                | 200.24                          |
| Fibular collateral ligament             | 305                  | Tendon/Ligament                  |                                                 | 1142                | 0.35                            |
| Fibularis brevis m.                     | 52954                | Muscle                           |                                                 | 1090                | 57.72                           |
| Fibularis longus m.                     | 129684               | Muscle                           |                                                 | 1090                | 141.36                          |
| Flexor carpi radialis m.                | 56974                | Muscle                           |                                                 | 1090                | 62.10                           |
| Flexor carpi ulnaris m.                 | 63893                | Muscle                           |                                                 | 1090                | 69.64                           |
| Flexor digiti minimi brevis m.          | 11457                | Muscle                           |                                                 | 1090                | 12.49                           |
| Flexor digiti minimi brevis m.          | 11248                | Muscle                           |                                                 | 1090                | 12.26                           |
| Flexor digitorum brevis m.              | 30426                | Muscle                           |                                                 | 1090                | 33.16                           |
| Flexor digitorum longus m.              | 62679                | Muscle                           |                                                 | 1090                | 68.32                           |
| Flexor digitorum profundus m.           | 207929               | Muscle                           |                                                 | 1090                | 226.64                          |
| Flexor digitorum superficialis m.       | 151250               | Muscle                           |                                                 | 1090                | 164.86                          |
| Flexor hallucis brevis m.               | 10032                | Muscle                           |                                                 | 1090                | 10.93                           |
| Flexor hallucis longus m.               | 155955               | Muscle                           |                                                 | 1090                | 169.99                          |
| Flexor pollicis brevis m.               | 23662                | Muscle                           |                                                 | 1090                | 25.79                           |
| Flexor pollicis longus m.               | 45785                | Muscle                           |                                                 | 1090                | 49.91                           |
| Fornix                                  | 1296                 | Brain (white matter)             |                                                 | 1041                | 1.35                            |
| Frontal bone                            | 124074               | Skull cortical                   |                                                 | 1908                | 236.73                          |

*Continued*
Table 2. Continued

| Structures | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|------------|----------------------|----------------------------------|-----------------------------------------------|--------------------|----------------------------------|
| Frontal lobe | 643551               | Brain                            |                                               | 1046               | 673.15                           |
| Frontal sinus | 577                 | Air                              |                                               | 1                  | 0.00                             |
| Gallbladder | 120901               | Gallbladder                       |                                               | 1071               | 129.48                           |
| Gastrocnemius m. | 676601          | Muscle                            |                                               | 1090               | 737.50                           |
| Gastroduodenal a. | 151               | Blood                            |                                               | 1050               | 0.16                             |
| Genioglossus m. | 4725               | Muscle                            |                                               | 1090               | 5.15                             |
| Geniohyoid m. | 14376               | Muscle                            |                                               | 1090               | 15.67                            |
| Globus pallidus | 5258               | Brain (gray matter)              |                                               | 1045               | 5.49                             |
| Gluteus maximus m. | 1202406           | Muscle                            |                                               | 1090               | 1310.62                          |
| Gluteus medius m. | 566187             | Muscle                            |                                               | 1090               | 617.14                           |
| Gluteus minimus m. | 228904            | Muscle                            |                                               | 1090               | 249.51                           |
| Gracilis m. | 137861               | Muscle                            |                                               | 1090               | 150.27                           |
| Great cardiac v. | 1340                | Blood                             |                                               | 1050               | 1.41                             |
| Great saphenous v. | 4193              | Blood                             |                                               | 1050               | 4.40                             |
| Hamate | 6827                 | Bone (cortical)                    |                                               | 1908               | 13.03                            |
| Heart | 471330               | Heart muscle                       |                                               | 1081               | 509.51                           |
| Hemi-azygos v. | 1511                | Blood                             |                                               | 1050               | 1.59                             |
| Hepatopancreatic ampulla b | 74          | Urinary bladder wall              |                                               | 1086               | 0.08                             |
| Hip bone | 671402               | Bone (cortical)                    |                                               | 1908               | 1281.04                          |
| Humerus | 200323               | Bone (cortical)                    |                                               | 1908               | 382.22                           |
| Humerus | 178333               | Bone (cortical)                    |                                               | 1908               | 340.26                           |
| Hyoglossus m. | 4894                | Muscle                            |                                               | 1090               | 5.33                             |
| Iliacus m. | 107410               | Muscle                            |                                               | 1090               | 117.08                           |
| Iliocostalis lumborum m. | 28812          | Muscle                            |                                               | 1090               | 31.41                            |
| Iliocostalis m. | 301899             | Muscle                            |                                               | 1090               | 329.07                           |
| Iliopsoas m. | 228082              | Muscle                            |                                               | 1090               | 248.61                           |
| Inferior epigastric a. | 17              | Blood                             |                                               | 1050               | 0.02                             |
| Inferior gemellus m. | 15816             | Muscle                            |                                               | 1090               | 17.24                            |
| Inferior gluteal a. | 269                | Blood                             |                                               | 1050               | 0.28                             |
| Inferior gluteal n. | 506                | Nerve                             |                                               | 1075               | 0.54                             |
| Inferior lingular segmental bronchus | 1034         | Bronchi                           |                                               | 1102               | 1.14                             |

Continued
| Structures                          | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|------------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|----------------------------------|
| Inferior lobar bronchus            | 2976                 | Bronchi                          |                                               | 1102                | 3.28                             |
| Inferior mesenteric a.             | 379                  | Blood                            |                                               | 1050                | 0.40                             |
| Inferior mesenteric v.             | 908                  | Blood                            |                                               | 1050                | 0.95                             |
| Inferior oblique m.                | 817                  | Muscle                           |                                               | 1090                | 0.89                             |
| Inferior obliquus capitis m.       | 20476                | Muscle                           |                                               | 1090                | 22.32                            |
| Inferior pulmonary v.              | 11292                | Blood                            |                                               | 1050                | 11.86                            |
| Inferior rectus m.                 | 1588                 | Muscle                           |                                               | 1090                | 1.73                             |
| Inferior sagittal sinus            | 573                  | Blood                            |                                               | 1050                | 0.60                             |
| Inferior vena cava                 | 69434                | Blood                            |                                               | 1050                | 72.91                            |
| Inferior vesical a.                | 70                   | Blood                            |                                               | 1050                | 0.07                             |
| Infraspinatus m.                   | 230155               | Muscle                           |                                               | 1090                | 250.87                           |
| Intercostal m.                     | 1153097              | Muscle                           |                                               | 1090                | 1256.88                          |
| Intermediate cuneiform             | 9622                 | Bone (cortical)                  |                                               | 1908                | 18.36                            |
| Intermediate hepatic v.            | 5775                 | Blood                            |                                               | 1050                | 6.06                             |
| Intermediate part of urethra①       | 55                   | Ureter/Urethra                    | Urinary bladder wall                          | 1086                | 0.06                             |
| Internal carotid a.                | 3123                 | Blood                            |                                               | 1050                | 3.28                             |
| Internal iliac a.                  | 660                  | Blood                            |                                               | 1050                | 0.69                             |
| Internal iliac v.                  | 116                  | Blood                            |                                               | 1050                | 0.12                             |
| Internal jugular v.                | 4627                 | Blood                            |                                               | 1050                | 4.86                             |
| Internal oblique abdominal m.      | 176340               | Muscle                           |                                               | 1090                | 192.21                           |
| Internal pudendal a.               | 127                  | Blood                            |                                               | 1050                | 0.13                             |
| Interspinous ligament (L I–L II)   | 366                  | Tendon/Ligament                  |                                               | 1142                | 0.42                             |
| Interspinous ligament (L II–L III) | 322                  | Tendon/Ligament                  |                                               | 1142                | 0.37                             |
| Interspinous ligament (L III–L IV) | 729                  | Tendon/Ligament                  |                                               | 1142                | 0.83                             |
| Interspinous ligament (L IV–L V)   | 624                  | Tendon/Ligament                  |                                               | 1142                | 0.71                             |
| Interspinous ligament (L V–sacrum) | 1147                 | Tendon/Ligament                  |                                               | 1142                | 1.31                             |
| Intervertebral disc (C II–C III)   | 1475                 | Intervertebral disc              |                                               | 1100                | 1.62                             |
| Intervertebral disc (C III–C IV)   | 1457                 | Intervertebral disc              |                                               | 1100                | 1.60                             |
| Intervertebral disc (C IV–C V)     | 1400                 | Intervertebral disc              |                                               | 1100                | 1.54                             |
| Intervertebral disc (C V–C VI)     | 1915                 | Intervertebral disc              |                                               | 1100                | 2.11                             |
| Intervertebral disc (C VI–C VII)   | 2464                 | Intervertebral disc              |                                               | 1100                | 2.71                             |

(Continued)
| Structures                        | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|----------------------------------|----------------------|----------------------------------|-------------------------------------------------|---------------------|---------------------------------|
| Intervertebral disc (C VII–T I) | 2635                 | Intervertebral disc              |                                                 | 1100                | 2.90                            |
| Intervertebral disc (L I–L II)  | 12552                | Intervertebral disc              |                                                 | 1100                | 13.81                           |
| Intervertebral disc (L II–L III)| 17279                | Intervertebral disc              |                                                 | 1100                | 19.01                           |
| Intervertebral disc (L III–L IV)| 18428                | Intervertebral disc              |                                                 | 1100                | 20.27                           |
| Intervertebral disc (L IV–L V)  | 21523                | Intervertebral disc              |                                                 | 1100                | 23.68                           |
| Intervertebral disc (L V–Sacrum)| 16300                | Intervertebral disc              |                                                 | 1100                | 17.93                           |
| Intervertebral disc (T I–T II)  | 3046                 | Intervertebral disc              |                                                 | 1100                | 3.35                            |
| Intervertebral disc (T II–T III)| 2970                 | Intervertebral disc              |                                                 | 1100                | 3.27                            |
| Intervertebral disc (T III–T IV)| 3235                 | Intervertebral disc              |                                                 | 1100                | 3.56                            |
| Intervertebral disc (T IV–T V)  | 3414                 | Intervertebral disc              |                                                 | 1100                | 3.76                            |
| Intervertebral disc (T IX–T X)  | 6052                 | Intervertebral disc              |                                                 | 1100                | 6.66                            |
| Intervertebral disc (T V–T VI)  | 3606                 | Intervertebral disc              |                                                 | 1100                | 3.97                            |
| Intervertebral disc (T VI–T VII)| 3634                 | Intervertebral disc              |                                                 | 1100                | 4.00                            |
| Intervertebral disc (T VII–T VIII)| 4931               | Intervertebral disc              |                                                 | 1100                | 5.42                            |
| Intervertebral disc (T VIII–T IX)| 5417                | Intervertebral disc              |                                                 | 1100                | 5.96                            |
| Intervertebral disc (T X–T XI)  | 5865                 | Intervertebral disc              |                                                 | 1100                | 6.45                            |
| Intervertebral disc (T XI–T XII)| 8317                 | Intervertebral disc              |                                                 | 1100                | 9.15                            |
| Intervertebral disc (T XII–L I) | 10008                | Intervertebral disc              |                                                 | 1100                | 11.01                           |
| Ischiocavernosus m.             | 7463                 | Muscle                           |                                                 | 1090                | 8.13                            |
| Jejunum and ileum⁹               | 634989               | Small intestine                  | Urinary bladder wall                            | 1086                | 689.60                          |
| Kidney                           | 405956               | Kidney                           |                                                 | 1066                | 432.75                          |
| Lacrimal bone                    | 1508                 | Bone (cortical)                  |                                                 | 1908                | 2.88                            |
| Larynx                           | 2492                 | Cartilage                        |                                                 | 1100                | 2.04                            |
| Lateral basal segmental bronchus | 463                  | Bronchi                          |                                                 | 1102                | 0.51                            |
| Lateral crico-arytenoid m.       | 2771                 | Muscle                           |                                                 | 1090                | 3.02                            |
| Lateral cuneiform                | 11119                | Bone (cortical)                  |                                                 | 1908                | 21.22                           |
| Lateral mandibular incisor tooth | 641                  | Tooth                            |                                                 | 2180                | 1.40                            |
| Lateral maxillary incisor tooth  | 744                  | Tooth                            |                                                 | 2180                | 1.62                            |
| Lateral meniscus                 | 586                  | Meniscus                         |                                                 | 1100                | 0.64                            |
| Lateral pterygoid m.             | 21982                | Muscle                           |                                                 | 1090                | 23.96                           |
| Lateral rectus m.                | 1868                 | Muscle                           |                                                 | 1090                | 2.04                            |
Table 2. Continued

| Structures                                      | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|------------------------------------------------|----------------------|----------------------------------|-----------------------------------------------|--------------------|----------------------------------|
| Lateral segmental bronchus                      | 592                  | Bronchi                          |                                               | 1102               | 0.65                             |
| Latissimus dorsi m.                             | 489955               | Muscle                           |                                               | 1090               | 534.05                           |
| Left atrium                                     | 60060                | Heart muscle                     |                                               | 1081               | 64.92                            |
| Left coronary a.                                | 164                  | Blood                            |                                               | 1050               | 0.17                             |
| Left gastric a.                                 | 19                   | Blood                            |                                               | 1050               | 0.02                             |
| Left hepatic ductb                             | 1042                 | Urinary bladder wall             |                                               | 1086               | 1.13                             |
| Left hepatic v.                                 | 463                  | Blood                            |                                               | 1050               | 0.49                             |
| Left marginal a.                                | 272                  | Blood                            |                                               | 1050               | 0.29                             |
| Left ventricle                                  | 29555                | Heart muscle                     |                                               | 1081               | 31.95                            |
| Levator ani m.                                  | 28066                | Muscle                           |                                               | 1090               | 30.59                            |
| Levator palpebrae superioris m.                 | 1033                 | Muscle                           |                                               | 1090               | 1.13                             |
| Levator scapulae m.                             | 70957                | Muscle                           |                                               | 1090               | 77.34                            |
| Levator veli palatini                           | 3996                 | Muscle                           |                                               | 1090               | 4.36                             |
| Ligament of head of femur                      | 3069                 | Tendon/Ligament                  |                                               | 1142               | 3.50                             |
| Ligamentum flavum (L I–L II)                    | 1278                 | Tendon/Ligament                  |                                               | 1142               | 1.46                             |
| Ligamentum flavum (L II–L III)                  | 2177                 | Tendon/Ligament                  |                                               | 1142               | 2.49                             |
| Ligamentum flavum (L III–L IV)                  | 2432                 | Tendon/Ligament                  |                                               | 1142               | 2.78                             |
| Ligamentum flavum (L IV–L V)                    | 2544                 | Tendon/Ligament                  |                                               | 1142               | 2.91                             |
| Ligamentum flavum (L V–sacrum)                  | 2094                 | Tendon/Ligament                  |                                               | 1142               | 2.39                             |
| Liver                                           | 2025510              | Liver                            |                                               | 1079               | 2185.53                          |
| Iliolumbar a.                                   | 50                   | Blood                            |                                               | 1050               | 0.05                             |
| Longissimus capitis m.                          | 11299                | Muscle                           |                                               | 1090               | 12.32                            |
| Longissimus cervicis m.                         | 108146               | Muscle                           |                                               | 1090               | 117.88                           |
| Longissimus m.                                  | 215670               | Muscle                           |                                               | 1090               | 235.08                           |
| Longus capitis m.                               | 20392                | Muscle                           |                                               | 1090               | 22.23                            |
| Longus colli m.                                 | 33151                | Muscle                           |                                               | 1090               | 36.13                            |
| Lumbar vertebra (fifth)                         | 64122                | Bone (cortical)                  |                                               | 1908               | 122.34                           |
| Lumbar vertebra (first)                         | 57223                | Bone (cortical)                  |                                               | 1908               | 109.18                           |
| Lumbar vertebra (fourth)                        | 65315                | Bone (cortical)                  |                                               | 1908               | 124.62                           |
| Lumbar vertebra (second)                        | 59502                | Bone (cortical)                  |                                               | 1908               | 113.53                           |
| Lumbar vertebra (third)                         | 63579                | Bone (cortical)                  |                                               | 1908               | 121.31                           |

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Continued
| Structures                              | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|----------------------------------------|----------------------|---------------------------------|-----------------------------------------------|--------------------|--------------------------------|
| Lumbrical m.                           | 4781                 | Muscle                          |                                               | 1090               | 5.21                          |
| Lunate                                 | 4263                 | Bone (cortical)                 |                                               | 1908               | 8.13                          |
| Lung                                   | 5559526              | Lung                            |                                               | 394                | 2190.45                       |
| Main bronchus                          | 8404                 | Bronchi                         |                                               | 1102               | 9.26                          |
| Mandible                               | 88747                | Mandible                        |                                               | 1908               | 169.33                        |
| Mandibular canine tooth                | 958                  | Tooth                           |                                               | 2180               | 2.09                          |
| Mandibular molar tooth (first)         | 2504                 | Tooth                           |                                               | 2180               | 5.46                          |
| Mandibular molar tooth (second)        | 1039                 | Tooth                           |                                               | 2180               | 2.27                          |
| Mandibular premolar tooth (first)      | 841                  | Tooth                           |                                               | 2180               | 1.83                          |
| Mandibular premolar tooth (second)     | 1857                 | Tooth                           |                                               | 2180               | 4.05                          |
| Masseter m.                            | 59529                | Muscle                          |                                               | 1090               | 64.89                         |
| Maxilla                                | 1408                 | Skull cortical                  |                                               | 1908               | 2.69                          |
| Maxillary canine tooth                 | 1224                 | Tooth                           |                                               | 2180               | 2.67                          |
| Maxillary molar tooth (first)          | 2387                 | Tooth                           |                                               | 2180               | 5.20                          |
| Maxillary molar tooth (second)         | 2336                 | Tooth                           |                                               | 2180               | 5.09                          |
| Maxillary premolar tooth (first)       | 894                  | Tooth                           |                                               | 2180               | 1.95                          |
| Maxillary premolar tooth (second)      | 826                  | Tooth                           |                                               | 2180               | 1.80                          |
| Maxillary sinus                        | 19843                | Air                             |                                               | 1                  | 0.02                          |
| Medial basal segmental bronchus        | 765                  | Bronchi                         |                                               | 1102               | 0.84                          |
| Medial cuneiform                       | 20732                | Bone (cortical)                 |                                               | 1908               | 39.56                         |
| Medial mandibular incisor tooth        | 438                  | Tooth                           |                                               | 2180               | 0.95                          |
| Medial maxillary incisor tooth         | 998                  | Tooth                           |                                               | 2180               | 2.18                          |
| Medial meniscus                        | 511                  | Meniscus                        |                                               | 1100               | 0.56                          |
| Medial pterygoid m.                    | 22926                | Muscle                          |                                               | 1090               | 24.99                         |
| Medial rectus m.                       | 1679                 | Muscle                          |                                               | 1090               | 1.83                          |
| Medial segmental bronchus              | 394                  | Bronchi                         |                                               | 1102               | 0.43                          |
| Median n.                              | 4490                 | Nerve                           |                                               | 1075               | 4.83                          |
| Metacarpal bone (fifth)                | 9834                 | Bone (cortical)                 |                                               | 1908               | 18.76                         |
| Metacarpal bone (first)                | 12821                | Bone (cortical)                 |                                               | 1908               | 24.46                         |
| Metacarpal bone (fourth)               | 11714                | Bone (cortical)                 |                                               | 1908               | 22.35                         |
| Metacarpal bone (second)               | 16559                | Bone (cortical)                 |                                               | 1908               | 31.59                         |

*Continued*
| Structures                      | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|--------------------------------|----------------------|----------------------------------|-----------------------------------------------|--------------------|-------------------------------|
| Metacarpal bone (third)        | 14973                | Bone (cortical)                  |                                               | 1908               | 28.57                         |
| Metacarpal bone (third)        | 832                  | Bone (cortical)                  |                                               | 1908               | 1.59                          |
| Metatarsal bone (fifth)        | 20200                | Bone (cortical)                  |                                               | 1908               | 38.54                         |
| Metatarsal bone (first)        | 35661                | Bone (cortical)                  |                                               | 1908               | 68.04                         |
| Metatarsal bone (fourth)       | 14531                | Bone (cortical)                  |                                               | 1908               | 27.73                         |
| Metatarsal bone (second)       | 16989                | Bone (cortical)                  |                                               | 1908               | 32.42                         |
| Metatarsal bone (third)        | 14934                | Bone (cortical)                  |                                               | 1908               | 28.49                         |
| Middle cardiac v.              | 621                  | Blood                            |                                               | 1050               | 0.65                          |
| Middle lobar bronchus          | 498                  | Bronchi                          |                                               | 1102               | 0.55                          |
| Middle phalanx (fifth)         | 1709                 | Bone (cortical)                  |                                               | 1908               | 3.26                          |
| Middle phalanx (fifth)         | 1618                 | Bone (cortical)                  |                                               | 1908               | 3.09                          |
| Middle phalanx (fourth)        | 3242                 | Bone (cortical)                  |                                               | 1908               | 6.19                          |
| Middle phalanx (fourth)        | 1081                 | Bone (cortical)                  |                                               | 1908               | 2.06                          |
| Middle phalanx (second)        | 2959                 | Bone (cortical)                  |                                               | 1908               | 5.65                          |
| Middle phalanx (second)        | 2098                 | Bone (cortical)                  |                                               | 1908               | 4.00                          |
| Middle phalanx (third)         | 3567                 | Bone (cortical)                  |                                               | 1908               | 6.81                          |
| Middle phalanx (third)         | 1248                 | Bone (cortical)                  |                                               | 1908               | 2.38                          |
| Middle scalenus m.             | 16175                | Muscle                           |                                               | 1090               | 17.63                         |
| Mitral valve b                  | 1068                 | Cartilage                        |                                               | 1100               | 1.17                          |
| Mylohyoid m.                   | 11805                | Muscle                           |                                               | 1090               | 12.87                         |
| Nasal bone                     | 1513                 | Bone (cortical)                  |                                               | 1908               | 2.89                          |
| Nasal cavity                   | 24884                | Air                              |                                               | 1                  | 0.02                          |
| Navicular                      | 21746                | Bone (cortical)                  |                                               | 1908               | 41.49                         |
| Neurohypophysis                | 165                  | Hypophysis                       |                                               | 1053               | 0.17                          |
| Obturator a.                   | 179                  | Blood                            |                                               | 1050               | 0.19                          |
| Obturator externus m.          | 100148               | Muscle                           |                                               | 1090               | 109.16                        |
| Obturator internus m.          | 104060               | Muscle                           |                                               | 1090               | 113.43                        |
| Obturator n.                   | 1948                 | Nerve                            |                                               | 1075               | 2.09                          |
| Occipital bone                 | 93619                | Skull cortical                   |                                               | 1908               | 178.63                        |
| Occipital lobe                 | 188142               | Brain                            |                                               | 1046               | 196.80                        |
| Occipital sinus                | 158                  | Blood                            |                                               | 1050               | 0.17                          |
| Structures                      | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|--------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|---------------------------------|
| Omohyoid m.                    | 10326                | Muscle                           |                                               | 1090                | 11.26                           |
| Opponens digiti minimi m.      | 7415                 | Muscle                           |                                               | 1090                | 8.08                            |
| Opponens pollicis m.           | 12861                | Muscle                           |                                               | 1090                | 14.02                           |
| Optic n.                       | 2102                 | Nerve                            |                                               | 1075                | 2.26                            |
| Palatoglossus m.               | 465                  | Muscle                           |                                               | 1090                | 0.51                            |
| Palmar interossei m.           | 12093                | Muscle                           |                                               | 1090                | 13.18                           |
| Palmaris brevis m.             | 2255                 | Muscle                           |                                               | 1090                | 2.46                            |
| Palmaris longus m.             | 29351                | Muscle                           |                                               | 1090                | 31.99                           |
| Pancreas                       | 113805               | pancreas                         |                                               | 1087                | 123.71                          |
| Pancreatic duct<sup>b</sup>     | 114                  | Urinary bladder wall             |                                               | 1086                | 0.12                            |
| Parietal bone                  | 268496               | Skull cortical                   |                                               | 1908                | 512.29                          |
| Parietal lobe                  | 307372               | Brain                            |                                               | 1046                | 321.51                          |
| Parotid gland                  | 47885                | Salivary gland                   |                                               | 1048                | 50.18                           |
| Patella                        | 23082                | Bone (cortical)                  |                                               | 1908                | 44.04                           |
| Patella                        | 22560                | Bone (cortical)                  |                                               | 1908                | 43.04                           |
| Pectineus m.                   | 93609                | Muscle                           |                                               | 1090                | 102.03                          |
| Pectoralis major m.            | 478970               | Muscle                           |                                               | 1090                | 522.08                          |
| Pectoralis minor m.            | 43616                | Muscle                           |                                               | 1090                | 47.54                           |
| Pericardial cavity             | 229330               | Cerebrospinal fluid              |                                               | 1007                | 230.94                          |
| Pharynx                        | 1482                 | Pharynx                          |                                               | 1                   | 0.00                            |
| Piriformis m.                  | 76195                | Muscle                           |                                               | 1090                | 83.05                           |
| Pisiform                       | 1916                 | Bone (cortical)                  |                                               | 1908                | 3.66                            |
| Plantar interossei m.          | 35274                | Muscle                           |                                               | 1090                | 38.45                           |
| Plantaris m.                   | 18365                | Muscle                           |                                               | 1090                | 20.02                           |
| Popliteal a.                   | 1070                 | Blood                            |                                               | 1050                | 1.12                            |
| Popliteal v.                   | 1898                 | Blood                            |                                               | 1050                | 1.99                            |
| Popliteus m.                   | 43436                | Muscle                           |                                               | 1090                | 47.35                           |
| Posterior basal segmental bronchus | 4504           | Bronchi                          |                                               | 1102                | 4.96                            |
| Posterior basal segmental bronchus | 262            | Bronchi                          |                                               | 1102                | 0.29                            |
| Posterior crico-arytenoid m.   | 910                  | Muscle                           |                                               | 1090                | 0.99                            |
| Posterior cruciate ligament    | 702                  | Tendon/Ligament                  |                                               | 1142                | 0.80                            |

*Continued*
| Structures                          | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|------------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|----------------------------------|
| Posterior interventricular branch  | 37                   | Blood                            |                                               | 1050                | 0.04                             |
| Posterior longitudinal ligament    | 1351                 | Tendon/Ligament                  |                                               | 1142                | 1.54                             |
| Posterior rectus capitis major m.  | 10500                | Muscle                           |                                               | 1090                | 11.45                            |
| Posterior rectus capitis minor m.  | 5169                 | Muscle                           |                                               | 1090                | 5.63                             |
| Posterior root of fifth lumbar n.  | 1143                 | Nerve                            |                                               | 1075                | 1.23                             |
| Posterior root of first sacral n.  | 1408                 | Nerve                            |                                               | 1075                | 1.51                             |
| Posterior root of fourth lumbar n. | 596                  | Nerve                            |                                               | 1075                | 0.64                             |
| Posterior root of second lumbar n. | 172                  | Nerve                            |                                               | 1075                | 0.18                             |
| Posterior root of second sacral n. | 825                  | Nerve                            |                                               | 1075                | 0.89                             |
| Posterior root of third lumbar n.  | 255                  | Nerve                            |                                               | 1075                | 0.27                             |
| Posterior root of third sacral n.  | 508                  | Nerve                            |                                               | 1075                | 0.55                             |
| Posterior scalenus m.              | 43678                | Muscle                           |                                               | 1090                | 47.61                            |
| Posterior segmental bronchus        | 1104                 | Bronchi                          |                                               | 1102                | 1.22                             |
| Posterior superior serratus m.      | 16738                | Muscle                           |                                               | 1090                | 18.24                            |
| Posterior tibial a.                 | 3371                 | Blood                            |                                               | 1050                | 3.54                             |
| Posterior tibialis m.               | 166872               | Muscle                           |                                               | 1090                | 181.89                           |
| Preprostatic part of urethraa       | 20                   | Ureter/Urethra                   | Urinary bladder wall                          | 1086                | 0.02                             |
| Pronator quadratus m.               | 26236                | Muscle                           |                                               | 1090                | 28.60                            |
| Pronator teres m.                   | 47628                | Muscle                           |                                               | 1090                | 51.91                            |
| Proper hepatic a.                   | 86                   | Blood                            |                                               | 1050                | 0.09                             |
| Prostateb                           | 11524                | Prostate                         | Salivary gland                                 | 1048                | 12.08                            |
| Prostatic urethraa                  | 63                   | Ureter/Urethra                   | Urinary bladder wall                          | 1086                | 0.07                             |
| Proximal phalanx (fifth)            | 5029                 | Bone (cortical)                  |                                               | 1908                | 9.60                             |
| Proximal phalanx (fifth)            | 1006                 | Bone (cortical)                  |                                               | 1908                | 1.92                             |
| Proximal phalanx (first)            | 11330                | Bone (cortical)                  |                                               | 1908                | 21.62                            |
| Proximal phalanx (first)            | 4962                 | Bone (cortical)                  |                                               | 1908                | 9.47                             |
| Proximal phalanx (fourth)           | 7967                 | Bone (cortical)                  |                                               | 1908                | 15.20                            |
| Proximal phalanx (fourth)           | 1696                 | Bone (cortical)                  |                                               | 1908                | 3.24                             |
| Proximal phalanx (second)           | 8022                 | Bone (cortical)                  |                                               | 1908                | 15.31                            |
| Proximal phalanx (second)           | 2429                 | Bone (cortical)                  |                                               | 1908                | 4.63                             |
| Proximal phalanx (third)            | 9243                 | Bone (cortical)                  |                                               | 1908                | 17.64                            |
Table 2. Continued

| Structures                   | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|---------------------------------|
| Proximal phalanx (third)     | 1646                 | Bone (cortical)                  |                                               | 1908                | 3.14                            |
| Psoas major m.               | 334209               | Muscle                           |                                               | 1090                | 364.29                          |
| Pulmonary a.                 | 55026                | Blood                            |                                               | 1050                | 57.78                           |
| Pulmonary trunk              | 3327                 | Blood                            |                                               | 1050                | 3.49                            |
| Pulmonary valve              | 1411                 | Cartilage                        |                                               | 1100                | 1.55                            |
| Putamen                      | 17360                | Brain (gray matter)              |                                               | 1045                | 18.14                           |
| Quadratus femoris m.         | 51750                | Muscle                           |                                               | 1090                | 56.41                           |
| Quadratus lumborum m.        | 143118               | Muscle                           |                                               | 1090                | 156.00                          |
| Quadratus plantae m.         | 14728                | Muscle                           |                                               | 1090                | 16.05                           |
| Radial a.                    | 1651                 | Blood                            |                                               | 1050                | 1.73                            |
| Radial n.                    | 457                  | Nerve                            |                                               | 1075                | 0.49                            |
| Radius                       | 107692               | Bone (cortical)                  |                                               | 1908                | 205.48                          |
| Rectum                       | 113149               | Large intestine                  |                                               | 1088                | 123.11                          |
| Rectus abdominis m.          | 329625               | Muscle                           |                                               | 1090                | 359.29                          |
| Rectus capitis lateralis m.  | 2805                 | Muscle                           |                                               | 1090                | 3.06                            |
| Rectus femoris m.            | 354178               | Muscle                           |                                               | 1090                | 386.05                          |
| Renal v.                     | 15298                | Blood                            |                                               | 1050                | 16.06                           |
| Rhomboid major m.            | 81703                | Muscle                           |                                               | 1090                | 89.06                           |
| Rhomboid minor m.            | 8439                 | Muscle                           |                                               | 1090                | 9.20                            |
| Rib (eighth)                 | 99949                | Bone (cortical)                  |                                               | 1908                | 190.70                          |
| Rib (eleventh)               | 30168                | Bone (cortical)                  |                                               | 1908                | 57.56                           |
| Rib (fifth)                  | 83661                | Bone (cortical)                  |                                               | 1908                | 159.63                          |
| Rib (first)                  | 39267                | Bone (cortical)                  |                                               | 1908                | 74.92                           |
| Rib (fourth)                 | 72344                | Bone (cortical)                  |                                               | 1908                | 138.03                          |
| Rib (ninth)                  | 72496                | Bone (cortical)                  |                                               | 1908                | 138.32                          |
| Rib (second)                 | 45192                | Bone (cortical)                  |                                               | 1908                | 86.23                           |
| Rib (seventh)                | 121273               | Bone (cortical)                  |                                               | 1908                | 231.39                          |
| Rib (sixth)                  | 103318               | Bone (cortical)                  |                                               | 1908                | 197.13                          |
| Rib (tenth)                  | 50557                | Bone (cortical)                  |                                               | 1908                | 96.46                           |
| Rib (third)                  | 55217                | Bone (cortical)                  |                                               | 1908                | 105.35                          |
| Rib (twelfth)                | 14901                | Bone (cortical)                  |                                               | 1908                | 28.43                           |

Continued
Table 2. Continued

| Structures                      | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|--------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|----------------------------------|
| Right atrium                   | 105829               | Heart lumen                      |                                               | 1050                | 111.12                           |
| Right coronary a.              | 431                  | Blood                            |                                               | 1050                | 0.45                             |
| Right hepatic ductb            | 370                  |                                   | Urinary bladder wall                          | 1086                | 0.40                             |
| Right hepatic v.               | 7202                 | Blood                            |                                               | 1050                | 7.56                             |
| Right ventricle                | 91189                | Heart lumen                      |                                               | 1050                | 95.75                            |
| Sacrospinous ligament          | 1450                 | Tendon/Ligament                  |                                               | 1142                | 1.66                             |
| Sacrotuberous ligament         | 7126                 | Tendon/Ligament                  |                                               | 1142                | 8.14                             |
| Sacrum                         | 206057               | Bone (cortical)                  |                                               | 1908                | 393.16                           |
| Sartorius m.                   | 232275               | Muscle                           |                                               | 1090                | 253.18                           |
| Scaphoid                       | 6499                 | Bone (cortical)                  |                                               | 1908                | 12.40                            |
| Scapula                        | 187018               | Bone (cortical)                  |                                               | 1908                | 356.83                           |
| Sciatic n.                     | 33686                | Nerve                            |                                               | 1075                | 36.21                            |
| Semimembranosus m.             | 285635               | Muscle                           |                                               | 1090                | 311.34                           |
| Seminal vesiclea               | 3882                 | Seminal vesicle                  | Salivary gland                                 | 1048                | 4.07                             |
| Semispinalis capitiss m.       | 125220               | Muscle                           |                                               | 1090                | 136.49                           |
| Semispinalis cerviciss m.      | 103928               | Muscle                           |                                               | 1090                | 113.28                           |
| Semitendinosus m.              | 234665               | Muscle                           |                                               | 1090                | 255.78                           |
| Sigmoid colon                  | 81288                | Large intestine                  |                                               | 1088                | 88.44                            |
| Sigmoid sinus                  | 5950                 | Blood                            |                                               | 1050                | 6.25                             |
| Sinu-atrial nodal branch       | 6                    | Blood                            |                                               | 1050                | 0.01                             |
| Skin                           | 1610895              | Skin                             |                                               | 1109                | 1786.48                          |
| Small cardiac v.               | 157                  | Blood                            |                                               | 1050                | 0.16                             |
| Small saphenous v.             | 134                  | Blood                            |                                               | 1050                | 0.14                             |
| Soft palate                    | 1664                 | Muscle                           |                                               | 1090                | 1.81                             |
| Soleus m.                      | 624893               | Muscle                           |                                               | 1090                | 681.13                           |
| Sphenoidal sinus               | 5326                 | Air                              |                                               | 1                   | 0.01                             |
| Spinal cord                    | 39578                | Spinal cord                      |                                               | 1075                | 42.55                            |
| Spleen                         | 1019875              | Spleen                           |                                               | 1089                | 1110.64                          |
| Splenic a.                     | 428                  | Blood                            |                                               | 1050                | 0.45                             |
| Splenic v.                     | 4773                 | Blood                            |                                               | 1050                | 5.01                             |
| Splenius capitiss m.           | 74175                | Muscle                           |                                               | 1090                | 80.85                            |

Continued
| Structures                      | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|--------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|-------------------------------|
| Spongy urethra                 | 197                  | Ureter/Urethra                   | Urinary bladder wall                          | 1086                | 0.21                          |
| Sternocleidomastoid m.         | 101243               | Muscle                           |                                               | 1090                | 110.35                        |
| Sternohyoid m.                 | 19414                | Muscle                           |                                               | 1090                | 21.16                         |
| Sternothyroid m.               | 10821                | Muscle                           |                                               | 1090                | 11.79                         |
| Sternum                        | 72818                | Bone (cortical)                  |                                               | 1908                | 138.94                        |
| Stomach (luminal)              | 197999               | Stomach lumen                    |                                               | 1045                | 206.91                        |
| Straight sinus                 | 656                  | Blood                            |                                               | 1050                | 0.69                          |
| Styloglossus m.                | 2085                 | Muscle                           |                                               | 1090                | 2.27                          |
| Stylohyoid m.                  | 2806                 | Muscle                           |                                               | 1090                | 3.06                          |
| Stylopharyngeus m.             | 2298                 | Muscle                           |                                               | 1090                | 2.50                          |
| Subclavian a.                  | 3585                 | Blood                            |                                               | 1050                | 3.76                          |
| Subclavian v.                  | 25168                | Blood                            |                                               | 1050                | 26.43                         |
| Subclavius m.                  | 11287                | Muscle                           |                                               | 1090                | 12.30                         |
| Sublingual gland               | 6020                 | Salivary gland                   |                                               | 1048                | 6.31                          |
| Submandibular gland            | 20356                | Salivary gland                   |                                               | 1048                | 21.33                         |
| Subscapularis m.               | 305109               | Muscle                           |                                               | 1090                | 332.57                        |
| Superficial fibular n.         | 1176                 | Nerve                            |                                               | 1075                | 1.26                          |
| Superficial transverse perineal m. | 1471      | Muscle                           |                                               | 1090                | 1.60                          |
| Superior gemellus m.           | 10618                | Muscle                           |                                               | 1090                | 11.57                         |
| Superior gluteal a.            | 317                  | Blood                            |                                               | 1050                | 0.33                          |
| Superior gluteal n.            | 347                  | Nerve                            |                                               | 1075                | 0.37                          |
| Superior lingual segmental bronchus | 1022               | Bronchi                          |                                               | 1102                | 1.13                          |
| Superior lobar bronchus         | 1878                 | Bronchi                          |                                               | 1102                | 2.07                          |
| Superior mesenteric a.         | 1957                 | Blood                            |                                               | 1050                | 2.05                          |
| Superior mesenteric v.         | 6547                 | Blood                            |                                               | 1050                | 6.87                          |
| Superior oblique m.            | 696                  | Muscle                           |                                               | 1090                | 0.76                          |
| Superior obliquus capitis m.    | 10069                | Muscle                           |                                               | 1090                | 10.98                         |
| Superior pulmonary v.          | 15171                | Blood                            |                                               | 1050                | 15.93                         |
| Superior rectus m.             | 935                  | Muscle                           |                                               | 1090                | 1.02                          |
| Superior sagittal sinus         | 9145                 | Blood                            |                                               | 1050                | 9.60                          |
| Superior segmental bronchus     | 1405                 | Bronchi                          |                                               | 1102                | 1.55                          |
The table below continues with the structural components and their respective densities and weights, calculated based on the number of voxels and specific substitution structures from a Virtual Population. The densities are measured in kg/m³, and the weights are calculated in grams (g), with the conversion factor of 1 g = 0.000001 kg.

| Structures                        | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|----------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|-------------------------------|
| Superior vena cava              | 9136                 | Blood                            |                                               | 1050                | 9.59                          |
| Supinator m.                    | 43718                | Muscle                           |                                               | 1090                | 47.65                         |
| Supraspinatus m.                | 126043               | Muscle                           |                                               | 1090                | 137.39                        |
| Supraspinous ligament            | 1803                 | Tendon/Ligament                   |                                               | 1142                | 2.06                          |
| Talus                            | 70679                | Bone (cortical)                   |                                               | 1908                | 134.86                        |
| Temporal bone                   | 146314               | Skull cortical                    |                                               | 1908                | 279.17                        |
| Temporal lobe                   | 393665               | Brain                            |                                               | 1046                | 411.77                        |
| Temporal m.                     | 108724               | Muscle                           |                                               | 1090                | 118.51                        |
| Tensor fasciae latae m.         | 105107               | Muscle                           |                                               | 1090                | 114.57                        |
| Tensor veli palatini            | 1546                 | Muscle                           |                                               | 1090                | 1.69                          |
| Teres major m.                  | 156281               | Muscle                           |                                               | 1090                | 170.35                        |
| Teres minor m.                  | 63583                | Muscle                           |                                               | 1090                | 69.31                         |
| Testis                           | 22741                | Testis                           |                                               | 1082                | 24.61                         |
| Thalamus*                       | 23275                | Thalamus                          | Brain                                         | 1046                | 24.35                         |
| Thoracic vertebra (eighth)      | 32639                | Vertebrae                        |                                               | 1908                | 62.28                         |
| Thoracic vertebra (eleventh)    | 43801                | Vertebrae                        |                                               | 1908                | 83.57                         |
| Thoracic vertebra (fifth)       | 28291                | Vertebrae                        |                                               | 1908                | 53.98                         |
| Thoracic vertebra (first)       | 28953                | Vertebrae                        |                                               | 1908                | 55.24                         |
| Thoracic vertebra (fourth)      | 26982                | Vertebrae                        |                                               | 1908                | 51.48                         |
| Thoracic vertebra (ninth)       | 34628                | Vertebrae                        |                                               | 1908                | 66.07                         |
| Thoracic vertebra (second)      | 29413                | Vertebrae                        |                                               | 1908                | 56.12                         |
| Thoracic vertebra (seventh)     | 31619                | Vertebrae                        |                                               | 1908                | 60.33                         |
| Thoracic vertebra (sixth)       | 30912                | Vertebrae                        |                                               | 1908                | 58.98                         |
| Thoracic vertebra (tenth)       | 38573                | Vertebrae                        |                                               | 1908                | 73.60                         |
| Thyroid gland*                  | 17563                | Thyroid gland                     | Salivary gland                                 | 1048                | 18.41                         |
| Tibia                           | 623990               | Bone (cortical)                   |                                               | 1908                | 1190.57                       |
| Tibial collateral ligament      | 870                  | Tendon/Ligament                   |                                               | 1142                | 0.99                          |
| Tibial n.                       | 19                   | Nerve                            |                                               | 1075                | 0.02                          |

Continued
phantoms were also identical [15]. Regarding the total weight, the VK-phantom male and HDRK man were 58 kg and 68 kg, respectively (the actual man’s weight was 55 kg). The source images of the VK-phantom female and HDRK woman were identical, and the VK-phantom and HDRK woman had similar weights, 55 kg and 52 kg, respectively (the actual woman’s weight was 52 kg) (Table 4).

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### Table 2. Continued

| Structures                        | Number of voxels (A) | Structures in Virtual Population | Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|-----------------------------------|----------------------|----------------------------------|-----------------------------------------------|---------------------|----------------------------------|
| Tongue                            | 45432                | Tongue                           |                                               | 1090                | 49.52                            |
| Trachea*                          | 25286                | Trachea                          | Bronchi                                       | 1102                | 27.87                            |
| Transverse acetabular ligament    | 1406                 | Tendon/Ligament                  |                                               | 1142                | 1.61                             |
| Transverse colon                  | 252123               | Large intestine                  |                                               | 1088                | 274.31                           |
| Transverse sinus                  | 5745                 | Blood                            |                                               | 1050                | 6.03                             |
| Transversospinales m.             | 423987               | Muscle                           |                                               | 1090                | 462.15                           |
| Transversus abdominis m.          | 154582               | Muscle                           |                                               | 1090                | 168.49                           |
| Trapezium                         | 4933                 | Bone (cortical)                  |                                               | 1908                | 9.41                             |
| Trapezius m.                      | 320406               | Muscle                           |                                               | 1090                | 349.24                           |
| Trapezoïd                         | 3778                 | Bone (cortical)                  |                                               | 1908                | 7.21                             |
| Triceps brachii m.                | 674910               | Muscle                           |                                               | 1090                | 735.65                           |
| Tricuspid valve*                  | 1151                 | Cartilage                        |                                               | 1100                | 1.27                             |
| Triquetrum                        | 3488                 | Bone (cortical)                  |                                               | 1908                | 6.66                             |
| Tympanic cavity                   | 452                  | Air                              |                                               | 1                   | 0.00                             |
| Ulna                              | 123461               | Bone (cortical)                  |                                               | 1908                | 235.56                           |
| Ulnar a.                          | 864                  | Blood                            |                                               | 1050                | 0.91                             |
| Ulnar n.                          | 1464                 | Nerve                            |                                               | 1075                | 1.57                             |
| Ureter*                           | 2734                 | Ureter/Urethra                   | Urinary bladder wall                          | 1086                | 2.97                             |
| Urinary bladder (luminal)         | 3742                 | Urine                            |                                               | 1024                | 3.83                             |
| Urinary bladder (mural)           | 41575                | Urinary bladder wall             |                                               | 1086                | 45.15                            |
| Vastus intermedius m.             | 559200               | Muscle                           |                                               | 1090                | 609.53                           |
| Vastus lateralis m.               | 944874               | Muscle                           |                                               | 1090                | 1029.91                          |
| Vastus medialis m.                | 541804               | Muscle                           |                                               | 1090                | 590.57                           |
| Vertebral a.                      | 786                  | Blood                            |                                               | 1050                | 0.83                             |
| Zygomatic bone                    | 31918                | Bone (cortical)                  |                                               | 1908                | 60.90                            |

* Change in the structure of the optimal density on list of Virtual Population (2017) because density of structures in Virtual Population was incorrect.

* Assigned to the most similar structures in the Virtual Population (2017) because there was no structure on the list.

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Table 3. Listing of 459 structures of whole body in the VK-phantom female and the weight of each structure according to material density of Virtual Population (2017)

| Structures                                      | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|-------------------------------------------------|---------------------|----------------------------------|---------------------|--------------------------------|
| Abdominal aorta                                 | 12147               | Blood                            | 1050                | 12.75                          |
| Abductor digiti minimi m.                       | 636                 | Muscle                           | 1090                | 0.69                           |
| Abductor hallucis m.                            | 30659               | Muscle                           | 1090                | 33.42                          |
| Acromioclavicular ligament                      | 1222                | Tendon/Ligament                  | 1142                | 1.40                           |
| Adductor longus m.                              | 121655              | Muscle                           | 1090                | 132.60                         |
| Adductor magnus m.                              | 500596              | Muscle                           | 1090                | 545.65                         |
| Adrenal gland                                   | 12999               | Adrenal gland                    | 1028                | 13.36                          |
| Air                                             | 0                   | Air                              | 1                   | 0.00                           |
| Anal canal                                      | 50                  | Large intestine                  | 1088                | 0.05                           |
| Angular gyrus                                   | 46893               | Brain (gray matter)              | 1045                | 49.00                          |
| Anterior commissure                             | 8                   | Commissura anterior              | 1041                | 0.01                           |
| Anterior cruciate ligament                      | 2291                | Tendon/ligament                  | 1142                | 2.62                           |
| Anterior rectus capitis m.                      | 748                 | Muscle                           | 1090                | 0.82                           |
| Anterior scalenus m.                            | 10089               | Muscle                           | 1090                | 11.00                          |
| Anterior serratus m.                            | 52069               | Muscle                           | 1090                | 56.76                          |
| Arch of aorta                                   | 8940                | Blood                            | 1050                | 9.39                           |
| Aryepiglottis m.                                | 126                 | Muscle                           | 1090                | 0.14                           |
| Arytenoid cartilage                             | 371                 | Cartilage                        | 1100                | 0.41                           |
| Ascending aorta                                 | 11789               | Blood                            | 1050                | 12.38                          |
| Ascending colon                                 | 157441              | Large intestine                  | 1088                | 171.30                         |
| Basal nucleus                                   | 20849               | Brain (gray matter)              | 1045                | 21.79                          |
| Biceps brachii m.                               | 107529              | Muscle                           | 1090                | 117.21                         |
| Biceps brachii(long head)                       | 689                 | Muscle                           | 1090                | 0.75                           |
| Biceps femoris long head m.                     | 146219              | Muscle                           | 1090                | 159.38                         |
| Biceps femoris short head m.                    | 65377               | Muscle                           | 1090                | 71.26                          |
| Brachialis m.                                   | 142515              | Muscle                           | 1090                | 155.34                         |
| Brachiocephalic trunk                           | 2498                | Blood                            | 1050                | 2.62                           |
| Brachiocephalic v.                              | 7294                | Blood                            | 1050                | 7.66                           |
| Brachioradialis m.                              | 5736                | Muscle                           | 1090                | 6.25                           |
| Brain (ventricle)                               | 5654                | Cerebrospinal fluid              | 1007                | 5.69                           |
| Brain (white matter)                            | 87493               | Brain (white matter)             | 1041                | 91.08                          |

Continued
| Structures                      | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|--------------------------------|---------------------|----------------------------------|---------------------|-------------------------------|
| Breast                         | 242734              | Breast fat                       | 911                 | 221.13                        |
| Buccinator m.                  | 6894                | Muscle                           | 1090                | 7.51                          |
| Calcaneum                      | 102910              | Bone (cortical)                  | 1908                | 196.35                        |
| Capitate                       | 4616                | Bone (cortical)                  | 1908                | 8.81                          |
| Cecum                          | 53664               | Large intestine                  | 1088                | 58.39                         |
| Celiac trunk                   | 315                 | Blood                            | 1050                | 0.33                          |
| Cerebellum                     | 112294              | Cerebellum                       | 1046                | 117.46                        |
| Cerebrum                       | 82935               | Brain                            | 1046                | 86.75                         |
| Cervical vertebra (fifth)      | 7890                | Vertebrae                        | 1908                | 15.05                         |
| Cervical vertebra (first)      | 10158               | Vertebrae                        | 1908                | 19.38                         |
| Cervical vertebra (fourth)     | 7566                | Vertebrae                        | 1908                | 14.44                         |
| Cervical vertebra (second)     | 12201               | Vertebrae                        | 1908                | 23.28                         |
| Cervical vertebra (seventh)    | 10168               | Vertebrae                        | 1908                | 19.40                         |
| Cervical vertebra (sixth)      | 9393                | Vertebrae                        | 1908                | 17.92                         |
| Cervical vertebra (third)      | 7519                | Vertebrae                        | 1908                | 14.35                         |
| Cingulate gyrus                | 23808               | Brain (gray matter)              | 1045                | 24.88                         |
| Clavicle                       | 38424               | Bone (cortical)                  | 1908                | 73.31                         |
| Coccyx                         | 1624                | Bone (cortical)                  | 1908                | 3.10                          |
| Common bile duct               | 2276                | Bile                             | 928                 | 2.11                          |
| Common carotid a.              | 6442                | Blood                            | 1050                | 6.76                          |
| Common fibular n.              | 8988                | Nerve                            | 1075                | 9.66                          |
| Common hepatic a.              | 168                 | Blood                            | 1050                | 0.18                          |
| Common iliac a.                | 2056                | Blood                            | 1050                | 2.16                          |
| Coraco-acromial ligament       | 619                 | Tendon/Ligament                  | 1142                | 0.71                          |
| Coracobrachialis m.            | 15056               | Muscle                           | 1090                | 16.41                         |
| Coracoclavicular ligament      | 2253                | Tendon/Ligament                  | 1142                | 2.57                          |
| Coracohumeral ligament         | 363                 | Tendon/Ligament                  | 1142                | 0.41                          |
| Corniculate cartilage          | 38                  | Cartilage                        | 1100                | 0.04                          |
| Coronary sinus                 | 1098                | Blood                            | 1050                | 1.15                          |
| Costal cartilage               | 85302               | Cartilage                        | 1100                | 93.83                         |
| Cranium without mandible       | 545166              | Skull cortical                   | 1908                | 1040.18                       |
| Structures                      | Number of voxel (A) | Structures of Virtual Population | "Substitution structures from Virtual Population" | Density [kg/m³] | Weight (g) (A X B X 0.000001) |
|--------------------------------|---------------------|----------------------------------|-----------------------------------------------|----------------|-------------------------------|
| Cricoid cartilage              | 2270                | Cartilage                        |                                               | 1100           | 2.50                          |
| Cricothyroid ligament          | 95                  | Tendon/Ligament                  |                                               | 1142           | 0.11                          |
| Cricothyroid m.                | 1112                | Muscle                           |                                               | 1090           | 1.21                          |
| Cuboid                         | 18793               | Bone (cortical)                  |                                               | 1908           | 35.86                         |
| Cuneus                         | 60164               | Bone (cortical)                  |                                               | 1908           | 114.79                        |
| Cystic duct<sup>b</sup>        | 1350                | Bile                             |                                               | 928            | 1.47                          |
| Deep fibular n.                | 951                 | Nerve                            |                                               | 1075           | 1.02                          |
| Deltoid m.                     | 228273              | Muscle                           |                                               | 1090           | 248.82                        |
| Dentate gyrus                  | 721                 | Brain (gray matter)              |                                               | 1045           | 0.75                          |
| Descending colon               | 296281              | Large intestine                  |                                               | 1088           | 322.35                        |
| Diaphragm                      | 228022              | Diaphragm                        |                                               | 1090           | 248.54                        |
| Digastric m.                   | 7442                | Muscle                           |                                               | 1090           | 8.11                          |
| Distal phalanx (fifth)         | 348                 | Bone (cortical)                  |                                               | 1908           | 0.66                          |
| Distal phalanx (fifth)         | 175                 | Bone (cortical)                  |                                               | 1908           | 0.33                          |
| Distal phalanx (first)         | 2841                | Bone (cortical)                  |                                               | 1908           | 5.42                          |
| Distal phalanx (first)         | 155                 | Bone (cortical)                  |                                               | 1908           | 0.30                          |
| Distal phalanx (fourth)        | 670                 | Bone (cortical)                  |                                               | 1908           | 1.28                          |
| Distal phalanx (fourth)        | 524                 | Bone (cortical)                  |                                               | 1908           | 1.00                          |
| Distal phalanx (second)        | 329                 | Bone (cortical)                  |                                               | 1908           | 0.63                          |
| Distal phalanx (second)        | 1017                | Bone (cortical)                  |                                               | 1908           | 1.94                          |
| Distal phalanx (third)         | 1461                | Bone (cortical)                  |                                               | 1908           | 2.79                          |
| Distal phalanx (third)         | 333                 | Bone (cortical)                  |                                               | 1908           | 0.64                          |
| Ear cartilage                  | 3651                | Cartilage                        |                                               | 1100           | 4.02                          |
| Ear fat                        | 16560               | Fat                              |                                               | 911            | 15.09                         |
| Ear skin                       | 7285                | Skin                             |                                               | 1109           | 8.08                          |
| Epiglottis                     | 777                 | Cartilage                        |                                               | 1100           | 0.85                          |
| Esophagus<sup>a</sup>          | 27944               | Esophagus                        | Muscle                                        | 1090           | 30.46                         |
| Extensor carpi radialis brevis m. | 11621            | Muscle                           |                                               | 1090           | 12.67                         |
| Extensor carpi radialis longus m. | 28681           | Muscle                           |                                               | 1090           | 31.26                         |
| Extensor carpi ulnaris m.      | 9698                | Muscle                           |                                               | 1090           | 10.57                         |
| Extensor digit minimi m.       | 2427                | Muscle                           |                                               | 1090           | 2.65                          |
Table 3. Continued

| Structures                        | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] | Weight (g) (A X B X 0.000001) |
|----------------------------------|---------------------|----------------------------------|----------------|---------------------------------|
| Extensor digitorum longus m.     | 28991               | Muscle                           | 1090           | 31.60                           |
| Extensor digitorum m.            | 21001               | Muscle                           | 1090           | 22.89                           |
| Extensor hallucis longus m.      | 5304                | Muscle                           | 1090           | 5.78                            |
| Extensor pollicis longus m.      | 5982                | Muscle                           | 1090           | 6.52                            |
| External acoustic meatusb        | 1163                | Bone (cortical)                  | 1908           | 2.22                            |
| External carotid a.              | 423                 | Blood                            | 1050           | 0.44                            |
| External iliac a.                | 3203                | Blood                            | 1050           | 3.36                            |
| External jugular v.              | 3494                | Blood                            | 1050           | 3.67                            |
| External oblique abdominis m.    | 146052              | Muscle                           | 1090           | 159.20                          |
| Eye (choroid)                    | 597                 | Blood                            | 1050           | 0.63                            |
| Eye (cornea)                     | 179                 | Eye (cornea)                     | 1051           | 0.19                            |
| Eye (lens)                       | 428                 | Eye (lens)                       | 1076           | 0.46                            |
| Eye (retina)b                    | 220                 | Nerve                            | 1075           | 0.24                            |
| Eye (sclera)                     | 567                 | Eye (sclera)                     | 1032           | 0.59                            |
| Eye (vitreous humor)             | 12864               | Eye (vitreous humor)             | 1005           | 12.93                           |
| Facial a.                        | 565                 | Blood                            | 1050           | 0.59                            |
| Fat                              | 32369521            | Fat                              | 911            | 29488.63                        |
| Fat pad                          | 884                 | Fat                              | 911            | 0.81                            |
| Femoral n.                       | 6498                | Nerve                            | 1075           | 6.99                            |
| Femur                            | 846518              | Bone (cortical)                  | 1908           | 1615.16                         |
| Fibula                           | 84632               | Bone (cortical)                  | 1908           | 161.48                          |
| Fibular collateral ligament      | 1070                | Tendon/Ligament                  | 1142           | 1.22                            |
| Fibularis brevis m.              | 77776               | Muscle                           | 1090           | 84.78                           |
| Fibularis longus m.              | 10045               | Muscle                           | 1090           | 10.95                           |
| Flexor carpi radialis m.         | 21378               | Muscle                           | 1090           | 23.30                           |
| Flexor carpi Ulnaris m.          | 22714               | Muscle                           | 1090           | 24.76                           |
| Flexor digiti minimi brevis m.   | 308                 | Muscle                           | 1090           | 0.34                            |
| Flexor digitorum brevis m.       | 17047               | Muscle                           | 1090           | 18.58                           |
| Flexor digitorum longus m.       | 23022               | Muscle                           | 1090           | 25.09                           |
| Flexor digitorum profundus m.    | 11982               | Muscle                           | 1090           | 13.06                           |
| Flexor digitorum superficialis m.| 11647               | Muscle                           | 1090           | 12.70                           |

Continued
| Structures                          | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.000001) |
|------------------------------------|---------------------|---------------------------------|---------------------|-------------------------------|
| Flexor hallucis longus m.          | 10034               | Muscle                          | 1090                | 10.94                         |
| Flexor pollicis brevis m.          | 554                 | Muscle                          | 1090                | 0.60                          |
| Flexor pollicis longus m.          | 9378                | Muscle                          | 1090                | 10.22                         |
| Gall bladder                       | 21013               | Gallbladder                     | 1071                | 22.50                         |
| Gastric a.                         | 644                 | Blood                           | 1050                | 0.68                          |
| Gastrocneysmus m.                  | 239943              | Muscle                          | 1090                | 261.54                        |
| Gastroduodenal a.                  | 205                 | Blood                           | 1050                | 0.22                          |
| Gastroepiploic a.                  | 474                 | Blood                           | 1050                | 0.50                          |
| Glenoid labrum                      | 344                 | Tendon/Ligament                 | 1142                | 0.39                          |
| Glossus m.                         | 2891                | Muscle                          | 1090                | 3.15                          |
| Gluteaus maximus m.                | 537591              | Muscle                          | 1090                | 585.97                        |
| Gluteaus medius m.                 | 341833              | Muscle                          | 1090                | 372.60                        |
| Gluteaus minimus m.                | 118579              | Muscle                          | 1090                | 129.25                        |
| Gracilis m.                        | 45521               | Muscle                          | 1090                | 49.62                         |
| Great cardiac v.                   | 1212                | Blood                           | 1050                | 1.27                          |
| Hamate                             | 3256                | Bone (cortical)                 | 1908                | 6.21                          |
| Heart                              | 155112              | Heart muscle                    | 1081                | 167.68                        |
| Hepatic a.                         | 399                 | Blood                           | 1050                | 0.42                          |
| Hepatic v.                         | 14576               | Blood                           | 1050                | 15.30                         |
| Hip bone                           | 506619              | Bone (cortical)                 | 1908                | 966.63                        |
| Hippocampus*                       | 2161                | Hippocampus                     | 1046                | 2.26                          |
| Humerus                            | 218778              | Bone (cortical)                 | 1908                | 417.43                        |
| Hypopysis                          | 726                 | Hypophysis                      | 1053                | 0.76                          |
| Hypothalamus                       | 665                 | Brain (gray matter)             | 1045                | 0.69                          |
| Iliacus m.                         | 37747               | Muscle                          | 1090                | 41.14                         |
| Iliocostalis m.                    | 160902              | Muscle                          | 1090                | 175.38                        |
| Iliopsoas m.                       | 118963              | Muscle                          | 1090                | 129.67                        |
| Inferior alveolar a.               | 34                  | Blood                           | 1050                | 0.04                          |
| Inferior frontal gyrus             | 36828               | Brain (gray matter)             | 1045                | 38.49                         |
| Inferior lobar bronchus            | 21313               | Bronchi                         | 1102                | 23.49                         |
| Inferior mesenteric a.             | 349                 | Blood                           | 1050                | 0.37                          |
| Structures                          | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] | Weight (g) (A X B X 0.000001) |
|------------------------------------|---------------------|---------------------------------|-----------------|--------------------------------|
| Inferior oblique m.                | 460                 | Muscle                          | 1090            | 0.50                           |
| Inferior obliquus capitis m.       | 11875               | Muscle                          | 1090            | 12.94                          |
| Inferior pulmonary v.              | 25872               | Blood                           | 1050            | 27.17                          |
| Inferior rectus m.                 | 1000                | Muscle                          | 1090            | 1.09                           |
| Inferior temporal gyrus            | 9291                | Brain (gray matter)             | 1045            | 9.71                           |
| Inferior vena cava                 | 41794               | Blood                           | 1050            | 43.88                          |
| Infraorbital a.                    | 62                  | Blood                           | 1050            | 0.07                           |
| Infraspinatus m.                   | 100805              | Muscle                          | 1090            | 109.88                         |
| Insula                             | 13019               | Brain (gray matter)             | 1045            | 13.60                          |
| Intercostal m.                     | 91632               | Muscle                          | 1090            | 99.88                          |
| Intermediate cuneiform             | 6904                | Bone (cortical)                 | 1908            | 13.17                          |
| Internal carotid a.                | 2077                | Blood                           | 1050            | 2.18                           |
| Internal iliac a.                  | 846                 | Blood                           | 1050            | 0.89                           |
| Internal jugular v.                | 21555               | Blood                           | 1050            | 22.63                          |
| Internal oblique abdominis m.      | 82423               | Muscle                          | 1090            | 89.84                          |
| Interspinous ligament (L I–L II)   | 102                 | Tendon/Ligament                 | 1142            | 0.12                           |
| Interspinous ligament (L II–L III) | 205                 | Tendon/Ligament                 | 1142            | 0.23                           |
| Interspinous ligament (L III–L IV) | 117                 | Tendon/Ligament                 | 1142            | 0.13                           |
| Interspinous ligament (L IV–L V)   | 60                  | Tendon/Ligament                 | 1142            | 0.07                           |
| Interspinous ligament (L V–Sacrum) | 40                  | Tendon/Ligament                 | 1142            | 0.05                           |
| Intervertebral disc (Cii–iii)      | 924                 | Intervertebral disc             | 1100            | 1.02                           |
| Intervertebral disc (Ciii–iv)      | 1192                | Intervertebral disc             | 1100            | 1.31                           |
| Intervertebral disc (Civ–v)        | 1171                | Intervertebral disc             | 1100            | 1.29                           |
| Intervertebral disc (Cv–vi)        | 1245                | Intervertebral disc             | 1100            | 1.37                           |
| Intervertebral disc (Cvi–vii)      | 1584                | Intervertebral disc             | 1100            | 1.74                           |
| Intervertebral disc (Cvii–Ti)      | 1314                | Intervertebral disc             | 1100            | 1.45                           |
| Intervertebral disc (Li–Liv)       | 12417               | Intervertebral disc             | 1100            | 13.66                          |
| Intervertebral disc (Lii–Lii)      | 9755                | Intervertebral disc             | 1100            | 10.73                          |
| Intervertebral disc (Li–Lii)       | 6324                | Intervertebral disc             | 1100            | 6.96                           |
| Intervertebral disc (Liv–Lv)       | 12849               | Intervertebral disc             | 1100            | 14.13                          |
| Intervertebral disc (Lv–Sacrum)    | 9412                | Intervertebral disc             | 1100            | 10.35                          |
Table 3. Continued

| Structures                        | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] | Weight (g) (A X B X 0.000001) |
|----------------------------------|---------------------|---------------------------------|-----------------|-------------------------------|
| Intervertebral disc (Tii–iii)    | 1348                | Intervertebral disc             | 1100            | 1.48                          |
| Intervertebral disc (Tiii–iv)    | 1456                | Intervertebral disc             | 1100            | 1.60                          |
| Intervertebral disc (Tiv–v)      | 1424                | Intervertebral disc             | 1100            | 1.57                          |
| Intervertebral disc (Tv–vi)      | 1725                | Intervertebral disc             | 1100            | 1.90                          |
| Intervertebral disc (Tv–vii)     | 1929                | Intervertebral disc             | 1100            | 2.12                          |
| Intervertebral disc (Tvii–viii)  | 2018                | Intervertebral disc             | 1100            | 2.22                          |
| Intervertebral disc (Tviii–ix)   | 2068                | Intervertebral disc             | 1100            | 2.27                          |
| Intervertebral disc (Tx–x)       | 2625                | Intervertebral disc             | 1100            | 2.89                          |
| Intervertebral disc (Tx–Txii)    | 2769                | Intervertebral disc             | 1100            | 3.05                          |
| Intervertebral disc (Txii–Li)    | 3715                | Intervertebral disc             | 1100            | 4.09                          |
| Kidney                           | 270722              | Kidney                          | 1066            | 288.59                        |
| Lat cuneiform                    | 8350                | Bone (cortical)                 | 1908            | 15.93                         |
| Lateral cricoarytenoid m.        | 152                 | Muscle                          | 1090            | 0.17                          |
| Lateral mandibular incisor tooth | 581                 | Tooth                           | 2180            | 1.27                          |
| Lateral maxillary incisor tooth  | 504                 | Tooth                           | 2180            | 1.10                          |
| Lateral meniscus                 | 1939                | Meniscus                        | 1100            | 2.13                          |
| Lateral occipital gyrus          | 4401                | Brain (gray matter)            | 1045            | 4.60                          |
| Lateral occipitotemporal gyrus   | 10257               | Brain (gray matter)            | 1045            | 10.72                         |
| Lateral orbital gyrus            | 7788                | Brain (gray matter)            | 1045            | 8.14                          |
| Lateral pterygoid m.             | 10026               | Muscle                          | 1090            | 10.93                         |
| Lateral rectus m.                | 1277                | Muscle                          | 1090            | 1.39                          |
| Latissimus dorsi m.              | 218394              | Muscle                          | 1090            | 238.05                        |
| Left atrium                      | 20052               | Heart lumen                     | 1050            | 21.05                         |
| Left coronary a.                 | 562                 | Blood                           | 1050            | 0.59                          |
| Left ventricle                   | 90170               | Heart lumen                     | 1050            | 94.68                         |
| Levator palpebrae superioris m.  | 924                 | Muscle                          | 1090            | 1.01                          |
| Levator scapulae m.              | 33975               | Muscle                          | 1090            | 37.03                         |
| Ligamentum flavum (L I–L II)     | 1025                | Tendon/Ligament                 | 1142            | 1.17                          |
| Ligamentum flavum (L II–L III)   | 1762                | Tendon/Ligament                 | 1142            | 2.01                          |

Continued
Table 3. Continued

| Structures                          | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|-------------------------------------|---------------------|---------------------------------|---------------------|----------------------------------|
| Ligamentum flavum (L III–L IV)      | 1901                | Tendon/Ligament                 | 1142                | 2.17                             |
| Ligamentum flavum (L IV–L V)        | 1834                | Tendon/Ligament                 | 1142                | 2.09                             |
| Ligamentum flavum (L V–Sacrum)      | 1898                | Tendon/Ligament                 | 1142                | 2.17                             |
| Lingual a.                          | 257                 | Blood                           | 1050                | 0.27                             |
| Lingual gyrus                       | 3468                | Brain (gray matter)             | 1045                | 3.62                             |
| Liver                               | 869590              | Liver                           | 1079                | 938.29                           |
| Longissimus m.                      | 179298              | Muscle                          | 1090                | 195.43                           |
| Longus capitis m.                   | 9903                | Muscle                          | 1090                | 10.79                            |
| Lumbar vertebra (fifth)             | 40395               | Bone (cortical)                 | 1908                | 77.07                            |
| Lumbar vertebra (fourth)            | 38547               | Bone (cortical)                 | 1908                | 73.55                            |
| Lumbar vertebrae (first)            | 29404               | Bone (cortical)                 | 1908                | 56.10                            |
| Lumbar vertebrae (second)           | 33096               | Bone (cortical)                 | 1908                | 63.15                            |
| Lumbar vertebrae (third)            | 39001               | Bone (cortical)                 | 1908                | 74.41                            |
| Lunate                              | 2897                | Bone (cortical)                 | 1908                | 5.53                             |
| Lung                                | 1352390             | Lung                            | 394                 | 532.84                           |
| Main bronchus                       | 7437                | Bronchi                         | 1102                | 8.20                             |
| Mandible                            | 50404               | Mandible                        | 1908                | 96.17                            |
| Mandibular canine tooth             | 919                 | Tooth                           | 2180                | 2.00                             |
| Mandibular premolar tooth (first)   | 803                 | Tooth                           | 2180                | 1.75                             |
| Mandibular premolar tooth (second)  | 621                 | Tooth                           | 2180                | 1.35                             |
| Manubrium                           | 15754               | Bone (cortical)                 | 1908                | 30.06                            |
| Masseter m.                         | 25610               | Muscle                          | 1090                | 27.91                            |
| Maxilla a.                          | 269                 | Blood                           | 1050                | 0.28                             |
| Maxilla canine tooth                | 923                 | Tooth                           | 2180                | 2.01                             |
| Maxilla premolar tooth (first)      | 905                 | Tooth                           | 2180                | 1.97                             |
| Maxilla premolar tooth (first)      | 1794                | Tooth                           | 2180                | 3.91                             |
| Maxilla premolar tooth (second)     | 852                 | Tooth                           | 2180                | 1.86                             |
| Maxilla premolar tooth (second)     | 2783                | Tooth                           | 2180                | 6.07                             |
| Med cuneiform                       | 15818               | Bone (cortical)                 | 1908                | 30.18                            |
| Medial frontal gyrus                | 28105               | Brain (gray matter)             | 1045                | 29.37                            |
| Medial mandibular incisor tooth    | 413                 | Tooth                           | 2180                | 0.90                             |

Continued
Table 3. Continued

| Structures                                      | Number of voxel (A) | Structures of Virtual Population | *Substitution structures from Virtual Population | Density [kg/m³] (B) | Weight (g) (A X B X 0.0000001) |
|------------------------------------------------|---------------------|----------------------------------|-----------------------------------------------|-------------------|---------------------------------|
| Medial maxillary incisor tooth                 | 667                 | Tooth                            |                                               | 2180              | 1.45                            |
| Medial meniscus                                | 1807                | Meniscus                         |                                               | 1100              | 1.99                            |
| Medial occipital gyrus                        | 4776                | Brain (gray matter)              |                                               | 1045              | 4.99                            |
| Medial occipitotemporal gyrus                 | 2325                | Brain (gray matter)              |                                               | 1045              | 2.43                            |
| Medial orbital gyrus                          | 5784                | Brain (gray matter)              |                                               | 1045              | 6.04                            |
| Medial pterygoid m.                           | 8982                | Muscle                           |                                               | 1090              | 9.79                            |
| Medial rectus m.                              | 1284                | Muscle                           |                                               | 1090              | 1.40                            |
| Median n.                                     | 3459                | Nerve                            |                                               | 1075              | 3.72                            |
| Medulla oblongata                             | 3131                | Medulla oblongata                |                                               | 1046              | 3.28                            |
| Metacarpal bone (fifth)                       | 5179                | Bone (cortical)                  |                                               | 1908              | 9.88                            |
| Metacarpal bone (first)                       | 7079                | Bone (cortical)                  |                                               | 1908              | 13.51                           |
| Metacarpal bone (fourth)                      | 6089                | Bone (cortical)                  |                                               | 1908              | 11.62                           |
| Metacarpal bone (second)                      | 9796                | Bone (cortical)                  |                                               | 1908              | 18.69                           |
| Metacarpal bone (third)                       | 8595                | Bone (cortical)                  |                                               | 1908              | 16.40                           |
| Metatarsal bone (fifth)                       | 13131               | Bone (cortical)                  |                                               | 1908              | 25.05                           |
| Metatarsal bone (first)                       | 26614               | Bone (cortical)                  |                                               | 1908              | 50.78                           |
| Metatarsal bone (fourth)                      | 11311               | Bone (cortical)                  |                                               | 1908              | 21.58                           |
| Metatarsal bone (second)                      | 12346               | Bone (cortical)                  |                                               | 1908              | 23.56                           |
| Metatarsal bone (third)                       | 11393               | Bone (cortical)                  |                                               | 1908              | 21.74                           |
| Midbrain                                      | 1993                | Midbrain                         |                                               | 1046              | 2.08                            |
| Middle cardiac v.                             | 175                 | Blood                            |                                               | 1050              | 0.18                            |
| Middle frontal gyrus                         | 57506               | Brain (gray matter)              |                                               | 1045              | 60.09                           |
| Middle lobar bronchus                         | 2756                | Cartilage                        |                                               | 1100              | 3.03                            |
| Middle meningeal a.                           | 524                 | Blood                            |                                               | 1050              | 0.55                            |
| Middle phalanx (fifth)                        | 745                 | Bone (cortical)                  |                                               | 1908              | 1.42                            |
| Middle phalanx (fifth)                        | 562                 | Bone (cortical)                  |                                               | 1908              | 1.07                            |
| Middle phalanx (fourth)                       | 1728                | Bone (cortical)                  |                                               | 1908              | 3.30                            |
| Middle phalanx (fourth)                       | 474                 | Bone (cortical)                  |                                               | 1908              | 0.90                            |
| Middle phalanx (second)                       | 1127                | Bone (cortical)                  |                                               | 1908              | 2.15                            |
| Middle phalanx (second)                       | 852                 | Bone (cortical)                  |                                               | 1908              | 1.63                            |
| Middle phalanx (third)                        | 1194                | Bone (cortical)                  |                                               | 1908              | 2.28                            |
| Structures                        | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] | Weight (g) (A X B X 0.0000001) |
|----------------------------------|---------------------|---------------------------------|-----------------|---------------------------------|
| Middle phalanx (third)           | 701                 | Bone (cortical)                 | 1908            | 1.34                            |
| Middle scalenus m.               | 4780                | Muscle                          | 1090            | 5.21                            |
| Middle temporal gyrus            | 27251               | Brain (gray matter)             | 1045            | 28.48                           |
| Multifidus m.                    | 17573               | Muscle                          | 1090            | 191.55                          |
| Mylohyoid m.                     | 3489                | Muscle                          | 1090            | 3.80                            |
| Nasal cavity                     | 19899               | Mucous membrane                 | 1102            | 21.93                           |
| Navicular                        | 14988               | Bone (cortical)                 | 1908            | 28.60                           |
| Oblique arytenoid m.             | 124                 | Muscle                          | 1090            | 0.14                            |
| Obturator n.                     | 2780                | Nerve                           | 1075            | 2.99                            |
| Occipital a.                     | 183                 | Blood                           | 1050            | 0.19                            |
| Opponens digiti minimi m.        | 1659                | Muscle                          | 1090            | 1.81                            |
| Opponens pollicis m.             | 12707               | Muscle                          | 1090            | 13.85                           |
| Optic nerve                      | 1559                | Nerve                           | 1075            | 1.68                            |
| Oral cavity                      | 8662                | Air                             | 1               | 0.01                            |
| Oral mucosa                      | 8078                | Mucous membrane                 | 1102            | 8.90                            |
| Ovary                            | 15354               | Ovary                           | 1048            | 16.09                           |
| Palmaris longus m.               | 36394               | Muscle                          | 1090            | 39.67                           |
| Pancreas                         | 45999               | Pancreas                        | 1087            | 50.00                           |
| Paracentral lobule               | 5827                | Brain (gray matter)             | 1045            | 6.09                            |
| Parahippocampal gyrus            | 16530               | Brain (gray matter)             | 1045            | 17.27                           |
| Parotid gland                    | 32171               | Salivary gland                  | 1048            | 33.72                           |
| Patella                          | 30913               | Bone (cortical)                 | 1908            | 58.98                           |
| Pectoralis major m.              | 178577              | Muscle                          | 1090            | 194.65                          |
| Pectoralis minor m.              | 31075               | Muscle                          | 1090            | 33.87                           |
| Pharynx                          | 6292                | Pharynx                         | 1               | 0.01                            |
| Pineal body                      | 51                  | Pineal body                     | 1053            | 0.05                            |
| Pisiform                         | 823                 | Bone (cortical)                 | 1908            | 1.57                            |
| Pons                             | 8168                | Pons                            | 1046            | 8.54                            |
| Popliteus m.                     | 14288               | Muscle                          | 1090            | 15.57                           |
| Portal v.                        | 7031                | Blood                           | 1050            | 7.38                            |
| Postcentral gyrus                | 46473               | Brain (gray matter)             | 1045            | 48.56                           |

*Continued*
Table 3. Continued

| Structures                        | Number of voxel (A) | Structures of Virtual Population    | Density [kg/m^3] (B) | Weight (g) (A X B X 0.0000001) |
|-----------------------------------|---------------------|-------------------------------------|----------------------|----------------------------------|
| Posterior auricular a.            | 75                  | Blood                               | 1050                 | 0.08                             |
| Posterior commissure              | 5                   | Commissura posterior                | 1041                 | 0.01                             |
| Posterior cricoarytenoid m.       | 596                 | Muscle                              | 1090                 | 0.65                             |
| Posterior cruciate ligament       | 2922                | Tendon/Ligament                     | 1142                 | 3.34                             |
| Posterior rectus capitis major m. | 7040                | Muscle                              | 1090                 | 7.67                             |
| Posterior rectus capitis minor m. | 2689                | Muscle                              | 1090                 | 2.93                             |
| Posterior scalenus m.             | 9098                | Muscle                              | 1090                 | 9.92                             |
| Precentral gyrus                  | 50331               | Brain (gray matter)                 | 1045                 | 52.60                            |
| Precuneus                         | 20237               | Brain (gray matter)                 | 1045                 | 21.15                            |
| Pronator quadratus m.             | 4578                | Muscle                              | 1090                 | 4.99                             |
| Pronator teres m.                 | 15996               | Muscle                              | 1090                 | 17.44                            |
| Proper hepatic a.                 | 74                  | Blood                               | 1050                 | 0.08                             |
| Proximal phalanx (fifth)          | 2376                | Bone (cortical)                     | 1908                 | 4.53                             |
| Proximal phalanx (fifth)          | 2043                | Bone (cortical)                     | 1908                 | 3.90                             |
| Proximal phalanx (first)          | 4805                | Bone (cortical)                     | 1908                 | 9.17                             |
| Proximal phalanx (first)          | 9465                | Bone (cortical)                     | 1908                 | 18.06                            |
| Proximal phalanx (fourth)         | 3799                | Bone (cortical)                     | 1908                 | 7.25                             |
| Proximal phalanx (fourth)         | 1917                | Bone (cortical)                     | 1908                 | 3.66                             |
| Proximal phalanx (second)         | 4338                | Bone (cortical)                     | 1908                 | 8.28                             |
| Proximal phalanx (second)         | 2705                | Bone (cortical)                     | 1908                 | 5.16                             |
| Proximal phalanx (third)          | 4932                | Bone (cortical)                     | 1908                 | 9.41                             |
| Proximal phalanx (third)          | 2346                | Bone (cortical)                     | 1908                 | 4.48                             |
| Psoas major m.                    | 91118               | Muscle                              | 1090                 | 99.32                            |
| Pulmonary a.                      | 38726               | Blood                               | 1050                 | 40.66                            |
| Pulmonary trunk                   | 17110               | Blood                               | 1050                 | 17.97                            |
| Quadratus lumborum m.             | 30803               | Muscle                              | 1090                 | 33.58                            |
| Radial n.                         | 2672                | Nerve                               | 1075                 | 2.87                             |
| Radius                            | 61730               | Bone (cortical)                     | 1908                 | 117.78                           |
| Rectum                            | 54295               | Large intestine                     | 1088                 | 59.07                            |
| Rectus abdominis m.               | 110433              | Muscle                              | 1090                 | 120.37                           |
| Rectus capitis lateralis m.       | 1098                | Muscle                              | 1090                 | 1.20                             |

Continued
| Structures                          | Number of voxel (A) | Structures of Virtual Population | Density [kg/m$^3$] | Weight (g) (A X B X 0.0000001) |
|------------------------------------|---------------------|----------------------------------|--------------------|---------------------------------|
| Rectus femoris m.                  | 148671              | Muscle                           | 1090               | 162.05                          |
| Rhomboid major m.                  | 47283               | Muscle                           | 1090               | 51.54                           |
| Rhomboid minor m.                  | 5297                | Muscle                           | 1090               | 5.77                            |
| Rib (first)                        | 10350               | Bone (cortical)                  | 1908               | 19.75                           |
| Rib (second)                       | 18344               | Bone (cortical)                  | 1908               | 35.00                           |
| Rib (third)                        | 20509               | Bone (cortical)                  | 1908               | 39.13                           |
| Rib (fourth)                       | 24891               | Bone (cortical)                  | 1908               | 47.49                           |
| Rib (fifth)                        | 27383               | Bone (cortical)                  | 1908               | 52.25                           |
| Rib (sixth)                        | 29431               | Bone (cortical)                  | 1908               | 56.15                           |
| Rib (seventh)                      | 24913               | Bone (cortical)                  | 1908               | 47.53                           |
| Rib (eighth)                       | 22004               | Bone (cortical)                  | 1908               | 41.98                           |
| Rib (ninth)                        | 17114               | Bone (cortical)                  | 1908               | 32.65                           |
| Rib (tenth)                        | 8424                | Bone (cortical)                  | 1908               | 16.07                           |
| Ribs                               | 50154               | Bone (cortical)                  | 1908               | 95.69                           |
| Right atrium                       | 112214              | Heart lumen                      | 1050               | 117.82                          |
| Right coronary a.                  | 415                 | Blood                            | 1050               | 0.44                            |
| Right ventricle                    | 165864              | Heart lumen                      | 1050               | 174.16                          |
| Sacrum                             | 148765              | Bone (cortical)                  | 1908               | 283.84                          |
| Sartorius m.                       | 83377               | Muscle                           | 1090               | 90.88                           |
| Scaphoid                           | 3736                | Bone (cortical)                  | 1908               | 7.13                            |
| Scapula                            | 85330               | Bone (cortical)                  | 1908               | 162.81                          |
| Sciatic n.                         | 10298               | Nerve                            | 1075               | 11.07                           |
| Semimembranosus m.                 | 168651              | Muscle                           | 1090               | 183.83                          |
| Semitendinosus m.                  | 106725              | Muscle                           | 1090               | 116.33                          |
| Sigmoid colon                      | 101543              | Large intestine                  | 1088               | 110.48                          |
| Skin                               | 1558967             | Skin                             | 1109               | 1728.89                         |
| Small intestine*                   | 694251              | Small intestine                  | Urinary bladder wall | 1086  | 753.96 |
| Soleus m.                          | 348105              | Muscle                           | 1090               | 379.43                          |
| Spinal cord                        | 22742               | Spinal cord                      | 1075               | 24.45                           |
| Spinalis m.                        | 10899               | Muscle                           | 1090               | 11.88                           |
| Spleen                             | 121485              | Spleen                           | 1089               | 132.30                          |
| Structures                  | Number of voxel (A) | Structures of Virtual Population | Density [kg/m³] | Weight (g) (A X B X 0.000001) |
|-----------------------------|---------------------|----------------------------------|----------------|-------------------------------|
| Splenic a.                  | 1884                | Blood                            | 1050           | 1.98                          |
| Sternocleidomastoid m.      | 53011               | Muscle                           | 1090           | 57.78                         |
| Sternohyoid m.              | 9184                | Muscle                           | 1090           | 10.01                         |
| Sternohyoid m.              | 5140                | Muscle                           | 1090           | 5.60                          |
| Sternum                     | 18055               | Bone (cortical)                  | 1908           | 34.45                         |
| Stomach*                    | 499500              | Stomach                          | 1086           | 542.46                        |
| Straight gyrus              | 14223               | Brain (gray matter)              | 1045           | 14.86                         |
| Subclavian a.               | 2381                | Blood                            | 1050           | 2.50                          |
| Subclavian v.               | 3638                | Blood                            | 1050           | 3.82                          |
| Subclavials m.              | 5075                | Muscle                           | 1090           | 5.53                          |
| Sublingual gland            | 4933                | Salivary gland                   | 1048           | 5.17                          |
| Submandibular gland         | 11051               | Salivary gland                   | 1048           | 11.58                         |
| Subscapularis m.            | 130233              | Muscle                           | 1090           | 141.95                        |
| Superficial fibular n.      | 188                 | Nerve                            | 1075           | 0.20                          |
| Superficial temporal a.     | 195                 | Blood                            | 1050           | 0.20                          |
| Superior alveolar a.        | 80                  | Blood                            | 1050           | 0.08                          |
| Superior frontal gyrus      | 85647               | Brain (gray matter)              | 1045           | 89.50                         |
| Superior laryngeal a.       | 33                  | Blood                            | 1050           | 0.03                          |
| Superior lobar bronchus     | 10635               | Bronchi                          | 1102           | 11.72                         |
| Superior mesenteric a.      | 617                 | Blood                            | 1050           | 0.65                          |
| Superior oblique m.         | 388                 | Muscle                           | 1090           | 0.42                          |
| Superior obliquus capitis m.| 2895                | Muscle                           | 1090           | 3.16                          |
| Superior parietal lobule    | 34949               | Brain (gray matter)              | 1045           | 36.52                         |
| Superior pulmonary v.       | 14837               | Blood                            | 1050           | 15.58                         |
| Superior rectus m.          | 842                 | Muscle                           | 1090           | 0.92                          |
| Superior temporal gyrus     | 45679               | Brain (gray matter)              | 1045           | 47.73                         |
| Superior thyroid a.         | 122                 | Blood                            | 1050           | 0.13                          |
| Superior vena cava          | 12572               | Blood                            | 1050           | 13.20                         |
| Supinator m.                | 18636               | Muscle                           | 1090           | 20.31                         |
| Supramarginal gyrus         | 44823               | Brain (gray matter)              | 1045           | 46.84                         |
| Supraspinatus m.            | 51211               | Muscle                           | 1090           | 55.82                         |

*Continued*
| Structures                        | Number of voxel (A) | Structures of Virtual Population | "Substitution structures from Virtual Population" | Density (kg/m³) | Weight (g) (A X B X 0.0000001) |
|----------------------------------|---------------------|----------------------------------|-----------------------------------------------|----------------|--------------------------------|
| Talus                            | 52202               | Bone (cortical)                  |                                              | 1908           | 99.60                          |
| Temporal m.                      | 27919               | Muscle                           |                                              | 1090           | 30.43                          |
| Teres major                      | 54497               | Muscle                           |                                              | 1090           | 59.40                          |
| Teres minor                      | 26438               | Muscle                           |                                              | 1090           | 28.82                          |
| Thalamusª                        | 7953                | Thalamus Brain                   |                                              | 1046           | 8.32                           |
| Thoracic aorta                   | 25576               | Blood                            |                                              | 1050           | 26.85                          |
| Thoracic vertebra (eighth)       | 17340               | Bone (cortical)                  |                                              | 1908           | 33.08                          |
| Thoracic vertebra (eleventh)     | 23400               | Bone (cortical)                  |                                              | 1908           | 44.65                          |
| Thoracic vertebra (fifth)        | 13372               | Bone (cortical)                  |                                              | 1908           | 25.51                          |
| Thoracic vertebra (first)        | 5411                | Bone (cortical)                  |                                              | 1908           | 10.32                          |
| Thoracic vertebra (fourth)       | 12310               | Bone (cortical)                  |                                              | 1908           | 23.49                          |
| Thoracic vertebra (ninth)        | 18996               | Bone (cortical)                  |                                              | 1908           | 36.24                          |
| Thoracic vertebra (second)       | 13616               | Bone (cortical)                  |                                              | 1908           | 25.98                          |
| Thoracic vertebra (seventh)      | 15454               | Bone (cortical)                  |                                              | 1908           | 29.49                          |
| Thoracic vertebra (sixth)        | 13679               | Bone (cortical)                  |                                              | 1908           | 26.10                          |
| Thoracic vertebra (tenth)        | 20711               | Bone (cortical)                  |                                              | 1908           | 39.52                          |
| Thoracic vertebra (third)        | 11471               | Bone (cortical)                  |                                              | 1908           | 21.89                          |
| Thoracic vertebra (Twelfth)      | 26518               | Bone (cortical)                  |                                              | 1908           | 50.60                          |
| Thyroarytenoid m.                | 182                 | Muscle                           |                                              | 1090           | 0.20                           |
| Thyroepiglottic ligament         | 351                 | Tendon/Ligament                  |                                              | 1142           | 0.40                           |
| Thyrohyoid membraneª             | 616                 | Tendon/Ligament                  |                                              | 1142           | 0.68                           |
| Thyroid cartilage                | 2673                | Cartilage                        |                                              | 1100           | 2.94                           |
| Thyroid glandª                   | 13668               | Thyroid gland Salivary gland     |                                              | 1048           | 14.32                          |
| Tibia                            | 521767              | Bone (cortical)                  |                                              | 1908           | 995.53                         |
| Tibial collateral ligament       | 3055                | Tendon/Ligament                  |                                              | 1142           | 3.49                           |
| Tibial n.                        | 21192               | Nerve                            |                                              | 1075           | 22.78                          |
| Tibialis ant m.                  | 119642              | Muscle                           |                                              | 1090           | 130.41                         |
| Tibialis post m.                 | 92482               | Muscle                           |                                              | 1090           | 100.81                         |
| Tongue                           | 42563               | Tongue                           |                                              | 1090           | 46.39                          |
| Tracheaª                         | 17447               | Trachea Bronchi                  |                                              | 1102           | 19.23                          |
| Transverse arytenoid m.          | 293                 | Muscle                           |                                              | 1090           | 0.32                           |

Continued
DISCUSSION

Of all the source materials available for designing a phantom for virtually testing electromagnetic dosimetry, segmented images based on the sectioned images from the Visible Human Project (VHP) [21], VK [15, 16, 22], and Visible Chinese Human (VCH) [23] are most appropriate because detailed structures of the human body can be distinguished in real color (>24 bits color) and high resolution (<0.2-mm³ voxels), compared with CT and MRI [3–6]. However, other
researchers have not been able to produce phantoms based on the original properties of the source materials, even when high-resolution sectioned images were used [3–6, 8, 24, 25]. In this study, we aimed to produce a VK-phantom male and female with properties closely resembling the original properties of the source materials (Table 1).

Tissues with different features should be distinguishable in detail in a phantom. In a phantom study, classification by tissue features rather than detailed structures is important. However, if a phantom does not have detailed structure, the phantom is unreliable because different tissues can be regarded as the same. In other phantom studies, including Virtual Family and ICRP publications, the muscles and their surrounding structures in the upper and lower limbs were not differentiated, although they are different tissues. In the orbit, the small vessels are not distinguished, although radiation can have differentially damaging effects on the various small vessels. In addition, many structures were not differentiated in other studies [1, 4, 5, 7, 14]. Therefore, in this study, a VK-phantom male with 583 structures and a VK-phantom female with 459 structures were constructed, and both were determined to be reliable in terms of their detailed structures (Tables 1–3).

Even tissues with identical features should be differentiated in a phantom, as well as tissues with different features. In dosimetry study on the possible effects of radiofrequency fields, particularly given the popularity of mobile phone use, the cerebrum is considered a very important organ in terms of identifying any possible associations between radiofrequency electromagnetic fields, including those from mobile phones, and brain tumors [26, 27]. To investigate such possible associations, the area exposed to these fields must be precisely determined, and an exact structure name area must be noted. In earlier studies, the cerebrum was regarded as comprising only two tissues: gray and white matter [1, 3–5, 20]. Therefore, we used VK-phantoms in which the cerebrum was divided along each gyrus (Tables 2, 3) [18, 22], and the absorption of each area was described and measured quantitatively.

Fig. 2. Process of acquiring voxel information from segmented images. (a) ID numbers were assigned serially to all segmented structures. (b) After segmented images were stacked in the computer memory, (c) voxel information (x, y and z coordinates and the ID number of each segmented structure) for a phantom was produced and saved in TXT format using VK-phantom.jar software. (d) The voxel number in the phantom was counted according to ID numbers using String_analysis.exe. For example, for the Blue box in (a), (c), and (d)), the voxel number of ID 2 (parietal bone) was 268,496.
| Structures            | VK-phantom | HDRK-man (Kim et al. [5]) | ICRP male phantom (Christ et al. [1]) | Virtual Family (Duke) (Christ et al. [1]) |
|-----------------------|------------|---------------------------|---------------------------------------|------------------------------------------|
| Adrenal gland         | 0          | 14                        | 14                                    | Adrenal glands 11                        |
| Bile                  | 1          | 1                         | Gall bladder contents 54.1            |                                          |
| Blood                 | 531        | 254                       | Blood 371.5                           |                                          |
| Blood vessel wall     | 6          | 9                         | Blood                                 |                                          |
| Bone (cortical)       | 10 91      | 9607                      | Skeleton 10450                        | Skeleton 7900                            |
| Bone marrow (red)     | 0          | 1068                      | Red bone marrow 960                   |                                          |
| Brain                 | 1635       | 1620                      | Brain 1450                            | Brain 1370                               |
| Brain (gray matter)   | 43         | 43                        | Brain                                 |                                          |
| Brain (white matter)  | 1          | 1                         | Esophagus (wall) 56                   |                                          |
| Breast gland          | 0          | 0                         | Breast, glandular tissue 10           |                                          |
| Bronchi               | 36         | 18                        | Breast, adipose tissue 15             |                                          |
| Bronchial lumen       | 0          | 0                         | Esophagus 40                          | Esophagus 40                             |
| Cartilage             | 8          | 6                         | Eye (cornea) 0.02                     | Prostate 17                              |
| Cerebellum            | 175        | 1                         | Eye (lens) 1                          | Lens 0.4                                 |
| Cerebrospinal fluid   | 241        | 2                         | Eye (sclera) 1                        | Lens 0.3                                 |
| Diaphragm             | 333        | 1                         | Eye (vitreous humor) 15               | Adipose tissue 11 800                    |
| Ductus deferens       | 3          | 1                         | Fat 8187                               | Gall bladder (wall + contents) 19        |
| Epididymis            | 11         | 1                         | Fat 23 400.2                          | Gall bladder wall 13.9                   |
| Esophagus             |            |                           | Eye (lens) 0.51                       | Eyes 15                                  |
| Eye (cornea)          | 0.02       | 1                         | Fat 8187                               | Gall bladder wall 13.9                   |
| Eye (lens)            | 1          | 1                         | Eye 21                                 | Gall bladder (wall + contents) 19        |
| Eye (sclera)          | 1          | 1                         | Eye 21                                 | Gall bladder wall 13.9                   |
| Eye (vitreous humor)  | 15         | 1                         | Fat 8187                               | Gall bladder wall 13.9                   |
| Fat                   | 8187       | 1                         | Gall bladder, Bile 13                 | Gall bladder wall 13.9                   |
| Gallbladder           | 129        | 1                         | Gall bladder contents 54.1            |                                          |

Continued
Table 4. Continued

| VK-phantom | HDRK-man (Kim et al. [5]) | ICRP male phantom (Christ et al. [1]) | Virtual Family (Duke) (Christ et al. [1]) |
|------------|--------------------------|--------------------------------------|-----------------------------------------|
| Structures | Weight (g) | Number | Structures | Weight (g) | Structures | Weight (g) | Structures | Weight (g) |
| Heart lumen | 207 | 2 | Heart contents | 510 | Heart contents (blood) |
| Heart muscle | 606 | 3 | Heart wall | 391 | Heart wall | 330 | Heart | 750 |
| Hypophysis | 1 | 2 | Pituitary gland | 0.6 |
| Intervertebral Disc | 174 | 23 |
| Kidney | 433 | 1 | Kidney | 359 | Kidneys | 310 | Kidney | 360 |
| Kidney (cortex) | 0 | 0 |
| Kidney (medulla) | 0 | 0 |
| Large intestine | 748 | 8 | Large intestine | 343 | Large intestinal wall | 370 | Colon wall | 530 |
| Large intestinal lumen | |
| Larynx | 0 | 0 |
| Liver | 2186 | 1 | Liver | 1417 | Liver | 1800 | Liver | 1240 |
| Lung | 2190 | 1 | Lungs | 1200 | Lung | 3800 |
| Lung (deflated) | 0 | 0 | Lung (deflated/inflated) | 1156 |
| Mandible | 169 | 1 | Breast | 23.3 |
| Meniscus | 1 | 2 |
| Mucous membrane | 0 | 0 | Oral mucosa | 21 | Oral mucosa | 35.8 |
| Muscle | 22 955 | 170 | Muscle | 23 300 | Muscle | 29 000 | Muscle | 34 100 |
| Nerve | 81 | 37 | Nerve |
| Pancreas | 124 | 1 | Pancreas | 126 | Pancreas | 140 | Pancreas | 70 |
| Pharynx | 0 | 1 |
| Prostate | 12 | 1 | Prostate | 12 |
| Salivary gland | 78 | 3 | Salivary gland | 87 | Salivary glands | 85 |
| Seminal vesicle | 4 | 1 |
| Skin | 1786 | 1 | Skin | 4260 | Skin | 3728 | Skin | 5500 |
| Skull cancellous | 0 | 0 |
| Skull cortical | 1519 | 8 |

Continued
Table 4. Continued

| Structures                  | VK-phantom     | HDRK-man ([Kim et al. [5]) | ICRP male phantom ([Christ et al. [11]) | Virtual Family (Duke) ([Christ et al. [11]) |
|-----------------------------|---------------|---------------------------|------------------------------------------|--------------------------------------------|
|                             | Weight (g)    | Number                    | Weight (g)                               | Weight (g)                                | Weight (g)                               |
| Small intestine             | 703           | 2                         | 602                                      | Small intestinal wall                      | 650                                      |
| Small intestinal lumen      |               |                           | Small Intestinal contents                |                                           | 350                                      |
| Spinal cord                 | 43            | 1                         | Spleen                                   | 177                                       | Spleen                                   |
| Spleen                      | 1111          | 1                         | 177                                      | 150                                       | 150                                      |
| Stomach                     | 1             | Stomach                   | 141                                      | Stomach wall                              | 150                                      |
| Stomach lumen               | 207           | 1                         | Stomach contents                         |                                           | 250                                      |
| Tendon/Ligament             | 49            | 22                        | Testis                                   | 25                                        | Testis                                   |
| Testis                      | 26            | 1                         | Testis                                   | 35                                        | 18                                       |
| Thalamus                    | 24            | 1                         | Thalamus                                 |                                           |                                          |
| Thymus                      | 0             | 0                         | 39                                       | Thymus                                    | 25                                       |
| Thyroid gland               | 18            | 1                         | 15                                       | Thyroid                                   | 20                                       |
| Tongue                      | 50            | 1                         | Tongue                                   | 73                                        |                                          |
| Tooth                       | 39            | 14                        | Tooth                                    | Tooth                                     | 50                                       |
| Trachea                     | 28            | 1                         | Trachea                                  | 10                                        |                                          |
| Ureter/Urethra              | 3             | 3                         | Ureters                                  |                                           | 16                                       |
| Urinary bladder wall        | 45            | 1                         | Urinary bladder                          | Urinary bladder wall                      | 50                                       |
| Urinary bladder contents    |               |                           |                                          |                                           | 200                                      |
| Vertebrae                   | 1022          | 19                        | Tonsils                                  | 3                                          |
| Extrathoracic region        |               |                           | Extrathoracic region                     | 39.4                                      |
| Gonad                       | 28            |                             | Lymphatic nodes                          | 138                                       |
| Extrathoracic region        | 73            |                             | Residual tissue                          | 20 458.4                                  |
| Total weight                | 58 kg         |                            | 68 kg                                    | 72 kg                                     | 69 kg                                    |
Furthermore, in most phantoms, accurate anatomical terms have not been used, even though this can result in incorrect descriptions of tissue features in the phantom, rendering the phantoms unreliable. For example, in some studies, the authors have referred to the thyroid gland or the thyroid cartilage (Table 4) [1, 4–6]. Official terminology from Terminologia Anatomica should be used [28], as in this study (Tables 2, 3).

The tissue density of Virtual Population [11] is the most reliable of all the phantom studies. Nevertheless, some of the Virtual Population densities are unreliable. The density of the small intestine (1030 kg/m$^3$) is between that of the bone marrow (red) (1029 kg/m$^3$) and eye (sclera) (1032 kg/m$^3$), although they are very different tissues; the small intestine consists of a mucous membrane, smooth muscle, vessels, and connective tissue, whereas the bone marrow (red) and eye (sclera) have densities similar to the blood and mucous membrane, respectively. The densities of the brain (gray matter), prostate, and seminal vesicles were identical (1045 kg/m$^3$), even though the tissue features of the structures are not identical. The density of the blood vessel wall, bronchi, and penis were identical (1102 kg/m$^3$), although the blood vessel wall, bronchi, and penis consist of smooth muscles with various connective tissues, cartilage with some smooth muscle, and blood in various connective tissues, respectively. In addition, in ICRP and HDRK [1, 4, 5], the density of each structure was not normal. Therefore, the densities of some structures were rearranged based on Virtual Population (marked with a superscript ‘a’ on Tables 2, 3).

Although the densities of the structures were rearranged or newly assigned, they were not accurate, because 104 tissue densities noted in Virtual Population could not be assigned to the 583 structures of the VK-phantom male and the 459 structures of the VK-phantom female. Therefore, in the near future, the densities of all detailed structures will need to be measured.

The voxel size of a phantom with detailed structures should definitely be small enough to accurately measure the effects of electromagnetic radiation. In the case of the VHP female phantom (voxel size, 6 × 6 × 6 mm$^3$) [3] and the VCH female phantom (voxel size, 2 × 2 × 4 mm$^3$) [6], the voxel size of the source images could not be used (VHP female, 0.33 mm$^3$; VCH female, 0.2 mm$^3$). In the case of the HDRK man [5] and the HDRK woman [4], phantoms of 2-mm$^3$-sized voxels were made, even though the source images had 0.2-mm$^3$-sized voxels [15–17]. In our preliminary test, we generated a phantom of the whole body (file size, 500 GB) from images of the original voxel size (0.2 mm$^3$); consequently, the phantom could never be analyzed on a personal computer. Therefore, we constructed phantoms with 1-mm$^3$-sized voxels, which is notably smaller than the voxel size of the phantoms described previously. As a result, very small structures could be observed in the VK-phantoms (e.g. sinus-atrial nodal branch, six voxels and 0.006 g; Table 1).

In the most recent studies, voxel phantoms are made of polygonal surface models based on MRI, CT, or sectioned images because polygonal surface models have several merits [1, 3–5, 20]. However, a VK-phantom male could never be made using polygonal surface modeling for the following reasons. First, a phantom with 583 structures comprises many polygons, even if it is based on low-resolution images (voxel size, >1-mm$^3$); consequently, the phantom could not be handled on a personal computer, even if the newest hardware and software were used. Second, polygonal surface models are deficient in that all of the information from the source images is not incorporated. When pixels of segmented images are reconstructed into polygonal surface models, the outer shapes of the models are smoothed. When polygonal surface models are converted into voxel models, the outer edges of the models are angulated. Because of the smoothing and angulating procedures, voxel information from the source images is lost [20]. Therefore, in this study, segmented images (1-mm$^3$-sized voxels) were converted directly into voxel models (VK-phantoms) in TXT format using house-developed software (VK-phantom.jar), without polygonal surface models.

Please note, voxel information in the VK-phantoms cannot be analyzed using commercial software for a virtual radiation test, because the dataset for a VK-phantom with a 1-mm$^3$-sized voxel is ~1 GB or more in size. Consequently, house-developed software (String_analysis.exe) was designed to analyze voxel information in the phantom.

In this study, a 583-structure VK-phantom male and a 459-structure VK-phantom female were constructed. In the VK-phantoms, voxel information of the whole body could be analyzed in detail (Tables 2, 3) by virtue of accurate segmentation, detailed structures, and small voxel size [15–18]. We continue to make new segmented images with new structures from the high-resolution sectioned images of VK. However, the new segmented images cannot be reconstructed into voxel models via polygonal surface modeling on even the newest personal computer. Therefore, future work will focus on converting convenient polygonal surface models into voxel models. For this work, improved surface modeling methods based on the segmented images [29] will be developed. Furthermore, the size of each structure in the VK-phantoms should be standardized. If the VK-phantoms are standardized and the mass density of each structure is precise, researchers will be able to measure the exact absorption in specific organs and tissues in the whole body. The segmented images and the house-developed software described in this study are distributed free of charge at neuroanatomy.kr even though most phantoms, including Virtual Population, are not free.

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CONFLICT OF INTEREST

The authors state that there is no conflict of interest.

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