CLAIMS

1. A system for classifying adipose tissue, comprising:

memory storing instructions; and

a processor coupled to the memory and configured to process the stored instructions to implement:

a segmentation module configured to:

acquire a medical image of a subject;

segment the medical image into a plurality of volumetric segments using a machine learning model,

wherein each of the plurality of volumetric segments comprises a respective segmentation mask corresponding to one selected from a plurality of adipose tissue types,

wherein the segmentation module is further configured to classify each voxel of the medical image with a label corresponding to one of: a background, a subcutaneous adipose tissue (SAT), and an intra-abdominal adipose tissue (IAAT),

wherein the segmentation module is further configured to classify each voxel with the label of subcutaneous adipose tissue (SAT) with one of: a superficial subcutaneous adipose tissue (SSAT) and a deep subcutaneous adipose tissue (DSAT), and to classify each voxel with the label of intra-abdominal adipose tissue (IAAT) with one of: an intraperitoneal adipose tissue (IPAT), a retroperitoneal adipose tissue (RPAT), and a paraspinal adipose tissue (PSAT),

wherein the segmentation module is further configured to determine a risk of cardiometabolic disease based on a quantification of the plurality of volumetric segments in the adipose tissue,

wherein the segmentation module is further configured to determine an unfavorable abdominal adipose tissue (AAT) distribution risk responsive to a higher amount of the intraperitoneal adipose tissue (IPAT) relative to a reference phenotype, and a lower amount of the deep subcutaneous adipose tissue (DSAT) relative to the reference phenotype.

2. The system as recited in claim 1, wherein the medical image comprises a three-dimensional (3D) volumetric image.

3. The system as recited in claim 1, wherein each of the plurality of adipose tissue types is selected from the group consisting of: a subcutaneous adipose tissue (SAT), an intra-abdominal adipose tissue (IAAT), a superficial subcutaneous adipose tissue (SSAT), a deep subcutaneous adipose tissue (DSAT), an intraperitoneal adipose tissue (IPAT), a retroperitoneal adipose tissue (RPAT), and a paraspinal adipose tissue (PSAT).

4. The system as recited in claim 1, wherein the segmentation module is further configured to provide a respective specific volume corresponding to each of the plurality of volumetric segments.

5. The system as recited in claim 1, wherein the segmentation module is further configured to convert a volume of each of the plurality of volumetric segments into a respective relative volume expressed as a percentage of a combined volume of all of the plurality of volumetric segments.

6. The system as recited in claim 1, wherein to segment the medical image further includes:

down-sampling the medical image for at least one down-sampling iteration to obtain an intermediate representation of the medical image; and

up-sampling the intermediate representation of the medical image for at least one up-sampling iteration to obtain the plurality of volumetric segments.

7. The system as recited in claim 9, wherein the segmentation module is further configured to provide a skip connection from one of the at least one down-sampling iteration to a corresponding at least one up-sampling iteration.

8. The system as recited in claim 1, wherein the segmentation module is further configured to train the machine learning model with a training data, wherein the training data includes augmented data.

9. The system as recited in claim 1, wherein the segmentation module is further configured to normalize an image volume of the medical image.

10. The system as recited in claim 1, wherein the machine learning model is a three-dimensional (3D) deep convolutional neural network.

11. The system as recited in claim 1, wherein the medical image comprises an output from one of the following: a Magnetic Resonance Imaging (MRI) scan, a Computed Tomography (CT) scan, and an electrical impedance tomography scan.

12. The system as recited in claim 1, wherein the segmentation module is further configured to overlay the segmentation masks on the medical image to obtain a visualization output, wherein each segmentation mask is provided with at least one predetermined visually-distinguishable characteristic.

13. The system as recited in claim 15, wherein the segmentation module is further configured to display the visualization output as a plurality of two-dimensional (2D) images, wherein each of the plurality of 2D images is representative of a cross section of the visualization output.

14. The system as recited in claim 1, wherein the segmentation module is further configured to determine a risk of a metabolic outcome based on the plurality of volumetric segments in the adipose tissue.

15. The system as recited in claim 1, wherein the segmentation module is further configured to determine a risk of gestational diabetes mellitus (GDM) based on a quantification of the plurality of volumetric segments in the adipose tissue.

16. The system as recited in claim 1, wherein the segmentation module is further configured to determine a risk of birth of large for gestational age (LGA) offspring based on a quantification of the plurality of volumetric segments in the adipose tissue.

17. The system as recited in claim 1, wherein the segmentation module is further configured to determine a risk of a disease based on a relative distribution of the plurality of volumetric segments in the adipose tissue.

18. The system as recited in claim 1, wherein the segmentation module is further configured to determine a risk of a disease based on a relative quantification of the plurality of volumetric segments in the adipose tissue.

19. The system as recited in any of claims 17 to 18, wherein the disease includes at least one of: type two diabetes and cardiovascular disease.

20. A method of classifying adipose tissue, method comprising:

acquiring a medical image of a subject;

segmenting the medical image into a plurality of volumetric segments using a machine learning model,

wherein each of the plurality of volumetric segments comprises a respective segmentation mask corresponding to one selected from a plurality of adipose tissue types;

wherein segmenting the medical image further comprising:

classifying each voxel of the medical image with a label corresponding to one of: a background, a subcutaneous adipose tissue (SAT), and an intra-abdominal adipose tissue (IAAT);

classifying each voxel with the label of subcutaneous adipose tissue (SAT) with one of: a superficial subcutaneous adipose tissue (SSAT) and a deep subcutaneous adipose tissue (DSAT);

classifying each voxel with the label of intra-abdominal adipose tissue (IAAT) with one of: an intraperitoneal adipose tissue (IPAT), a retroperitoneal adipose tissue (RPAT), and a paraspinal adipose tissue (PSAT);

determining a risk of cardiometabolic disease based on a quantification of the plurality of volumetric segments in the adipose tissue; and

determining an unfavorable abdominal adipose tissue (AAT) distribution risk responsive to a higher amount of the intraperitoneal adipose tissue (IPAT) relative to a reference phenotype, and a lower amount of the deep subcutaneous adipose tissue (DSAT) relative to the reference phenotype.