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(54) Method and apparatus for measuring distribution of body fat

Verfahren und Vorrichtung zur Messung der Verteilung von Körperfettgehalt

Procédé et dispositif de mesure de la répartition de la graisse corporelle

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Description

BACKGROUND OF THE INTENTION:

Field of the Invention:

[0001] The present invention relates to a method and an apparatus for measuring a body fat for a person, and more particularly, to a method and an apparatus for measuring a distribution of body fat for a human body.

Description of the Prior Art:

[0002] In the past, the weight of a person was frequently used as a factor to represent a personal health condition. But, recently, a rate of body fat for a person has becoming to be an important factor to represents the health condition for the person. Accordingly, various types of method and apparatus for measuring an amount of body fat have been developed and proposed. For instance, TOKUKAISHO No. 62-169023 discloses a technique for measuring an amount of body fat for a person by entering the personal data such as height, age, sex, etc., and measuring the weight for a person and the impedance between the extreme parts on a body of the person. In addition, TOKUHYOSHO No. 57-500900 discloses a technique for measuring the thickness of a fatty fascia. According to this technique, an ultrasonic pulse signal is applied to an animal from the rear side, and any received signal reflected from a boundary between a fatty fascia and a muscle fascia is detected. Then the time period between transmission and reception of the pulse signal is measured to determine the thickness of the fatty fascia. Furthermore, TOKUKAISHO No. 62-87139 discloses an estimating method for body fat. According to this method, subcutaneous fat on each part of a human body is measured by using an ultrasonic signal. Then the measurement is multiplied by a cross sectional area factor or a body fat estimation factor on each part of the body for producing an estimate of body fat on each part of the body. Thereafter, the individual estimates are integrated to determine whole body fat.

[0003] Recently, it has found that a risk for a person to get so called "adult (noncommunicable) diseases", such as diabetes, arteriosclerosis, etc., may vary depending upon the distribution of fat or whether he has a subcutaneous fat or a visceral fat, irrespective of the same rate of fat he has. Therefore, a method of measuring the distribution of fat by analyzing a tomographic image of an abdomen taken by CT or MRI has been proposed.

[0004] Such method, however, is problematic in that the analysis of the image is highly complex and CT may produce an exposure of X-ray to the human body.

[0005] Therefore, an object of the present invention is to provide a method and an apparatus for measuring a distribution of body fat, that can solve the problems of the prior art.

Summary of the Invention:

[0006] In order to attain such object, the prior art problems are solved, according to one aspect of the present invention, by providing a new and improved method of measuring a distribution of body fat for a human body, characterized in that it comprises the steps of: measuring a bioelectrical impedance and a thickness of abdominal subcutaneous fat, based on the personal data such as sex, age, height, weight, etc.; and calculating an area or an amount of abdominal visceral fat, based on the measurements of the bioelectrical impedance and the thickness of abdominal subcutaneous fat.

[0007] According to another aspect, the present invention provides a method of measuring a distribution of body fat for a human body, characterized in that it comprises the steps of: measuring a bioelectrical impedance and a thickness of abdominal subcutaneous fat, based on the personal data such as sex, age, height, weight, etc.; and calculating an area or an amount of abdominal subcutaneous fat, based on the measurements of the bioelectrical impedance and the thickness of abdominal subcutaneous fat.

[0008] According to further aspect, the present invention provides a method of measuring a distribution of body fat for a human body, characterized in that it comprises the steps of: measuring a bioelectrical impedance and a thickness of abdominal subcutaneous fat, based on the personal data such as sex, age, height, weight, etc.; and calculating an area or an amount of abdominal visceral fat and an area or an amount of abdominal subcutaneous fat, based on the measurements of the bioelectrical impedance and the thickness of abdominal subcutaneous fat.

[0009] According to yet further aspect, the present invention provides a method of measuring a distribution of body fat for a human body, characterized in that it comprises the steps of: measuring a bioelectrical impedance and a thickness of abdominal subcutaneous fat, based on the sex, age, height and weight of a person; measuring a girth of abdomen; and calculating an area or an amount of abdominal visceral fat, based on the measurements of the bioelectrical impedance, the thickness of abdominal subcutaneous fat and the girth of abdomen.

[0010] According to one embodiment of the present invention, said thickness of abdominal subcutaneous fat is measured by using an ultrasonic signal.

[0011] According to one embodiment of the present invention, said thickness of abdominal subcutaneous fat is measured by using a skin hold caliper.

[0012] According to yet further aspect, the present invention provides an apparatus for measuring a distribution of body fat for a human body, characterized in that it comprises: a first input unit that enters the personal data such as sex, age, height, weight, etc.; a measuring unit that measures a bioelectrical impedance; a second input unit that enters a thickness of abdominal subcutaneous fat; and an arithmetic element that calculates an area or an amount of abdominal visceral fat, based on the data from said first input unit, said measuring unit and said second input unit.

[0013] According to yet further aspect, the present invention provides an apparatus for measuring a distribution of body fat for a human body, characterized in that it comprises: a first input unit that enters the personal data such as sex, age, height, weight, etc.; a measuring unit that measures a bioelectrical impedance; a second input unit that enters a thickness of abdominal subcutaneous fat; and an arithmetic element that calculates an area or an amount of abdominal subcutaneous fat, based on the data from said first input unit, said measuring unit and said second input unit.

[0014] According to yet further aspect, the present invention provides an apparatus for measuring a distribution of body fat for a human body, characterized in that it comprises: a first input unit that enters the personal data such as sex, age, height, weight, etc.; a measuring unit that measures a bioelectrical impedance; a second input unit that enters a thickness of abdominal subcutaneous fat; a third input unit that enters a girth of abdomen; and an arithmetic element that calculates an area or an amount of abdominal visceral fat, based on the data from said first input unit, said measuring unit, said second input unit and said third input unit.

[0015] According to yet further aspect, the present invention provides an apparatus for measuring a distribution of body fat for human body, characterized in that it comprises: a first input unit that enters the personal data such as sex, age, height, weight, etc.; a measuring unit that measures a bioelectrical impedance; a second input unit that enters a thickness of abdominal subcutaneous fat; a third input unit that enters a girth of abdomen; and an arithmetic element that calculates an area or an amount of abdominal subcutaneous fat, based on the data from said first input unit, said measuring unit, said second input unit and said third input unit.

[0016] According to yet further aspect, the present invention provides an apparatus for measuring a distribution of body fat for human body, characterized in that it comprises: a first input unit that enters the personal data such as sex, age, height, weight, etc.; a measuring unit that measures a bioelectrical impedance; a second input unit that enters a thickness of abdominal subcutaneous fat; and an arithmetic element that calculates an area or an amount of abdominal visceral fat and an area or an amount of abdominal subcutaneous fat, based on the data from said first input unit, said measuring unit and said second input unit.

[0017] According to one embodiment of the present invention, said second input unit includes an ultrasonic probe.

[0018] According to another embodiment of the present invention, the data detected by said ultrasonic probe is transmitted to said arithmetic element via a radio communication means or an optical communication means

[0019] According to further embodiment of the present invention, said second input unit includes a skin hold caliper.

[0020] According to further embodiment of the present invention, the data detected by said skin hold caliper is transmitted to said arithmetic element via a radio communication means or an optical communication means

<u>Brief Description of the drawings</u>:

[0021] Now the preferred embodiments of the present invention will be described with reference to the accompanying drawings.

Fig. 1 is a perspective view representing an apparatus for measuring a body fat for a person according to a preferred embodiment of the present invention;

Fig. 2 is a schematic block diagram representing the circuit configuration of the body fat measuring apparatus, as shown in Fig. 1;

Fig. 3 is a perspective view representing an apparatus for measuring a body fat for a person according to another embodiment of the present invention;

Fig. 4 is a schematic block diagram representing the circuit configuration of the body fat measuring apparatus, as shown in Fig. 3;

Fig. 5 is a flow chart briefly representing the steps of measuring the distribution of body fat according to the present invention;

Figs. 6 and 7 are flow charts each representing in more detail the steps, as shown in Fig. 5;

Fig. 8 is a cross sectional view of subcutaneous fat in abdomen when it is assumed that the cross section of abdomen is considered as a true circle;

Fig. 9 is a view representing the correlation between a total amount of fat and a total area of fat in abdomen;

Fig. 10 is a view representing the correlation between a thickness and an area of abdominal subcutaneous fat;

Fig. 11 is a view representing the correlation between a total amount of fat and an area of abdominal visceral fat;
Fig. 12 is a view representing the correlation between a thickness of abdominal subcutaneous fat and a total amount of subcutaneous fat;
Fig. 13 is a view representing the correlation between a total subcutaneous fat and an area of abdominal subcutaneous fat;
Fig. 14 is a view representing the correlation between an amount of visceral fat and an area of abdominal visceral fat;
Fig. 15 is a view representing the correlation between a height, weight and thickness of subcutaneous fat, and a total amount of subcutaneous fat; and
Fig. 16 is a view representing the correlation between a product of waist size and thickness of subcutaneous fat, and an area of abdominal subcutaneous fat.

Description of the Preferred Embodiments:

[0022] Fig. 1 is a perspective view representing an apparatus for measuring a body fat for a person according to a preferred embodiment of the present invention. The body fat measuring apparatus includes a weight meter 10 with a fat meter included therein, and an ultrasonic probe 30 connected to the weight meter 10 via an electric cable 20. In this embodiment, some standard electric cable 20 is shown to connect the ultrasonic probe 30 with the weight meter 10. But it may possible that the measurement data obtained by the ultrasonic probe 30 is transmitted to the weight meter 10 via a radio frequency communication or an optical communication.

[0023] The weight meter 10 is provided with a power switch (not shown), pairs of foot electrodes 11 and 12, a display 13 and a data input portion 14 on the top of the meter housing. In addition, a weight sensor and a control circuit having an arithmetic component are included inside the housing of weight meter 10.

[0024] Fig. 2 is a schematic block diagram representing a circuit configuration of the body fat measuring apparatus, as shown in Fig. 1. As shown in Fig. 2, the weight meter 10 includes a control circuit 1 as the main component within the housing, as usual. The control circuit 1 functions to receive a data from data input switches on the data input portion 14, and a weight data detected by the weight sensor. In addition, it receives data signals from constant current electrode plates and voltage measuring electrode plates of the pairs of foot electrodes 11 and 12, and a data from the ultrasonic probe 30. Based on those data, the control circuit performs arithmetic operations, as described below, for indicating the results of the arithmetic operations on the display 13.

[0025] Alternative to the control circuit 1 and the data input switches 14 positioned on the weight meter 10, the similar control circuit 2 and the data input switches may be positioned on the ultrasonic probe 30, as shown in Fig. 2. In addition, instead of the electric cable 20, the radio frequency communication or optical communication may be done for data transmission between transmitter / receiver portions in the weight meter 10 and the ultrasonic probe 30, as indicated by a broken line in Fig. 2.

[0026] Fig. 3 is a perspective view representing an apparatus for measuring a body fat for a person according to another embodiment of the present invention. The body fat measuring apparatus includes a weight meter 10 with a fat meter included therein, and a skin hold caliper 40 connected to the weight meter 10 via an electric cable 20. In this embodiment, some standard electric cable 20 is shown to connect the skin hold caliper 40 with the weight meter 10. But, as already described earlier, it may possible that the measurement data obtained by the skin hold caliper 40 is transmitted to the weight meter 10 via a radio frequency communication or an optical communication.

[0027] Similar to the embodiment as above, the weight meter 10 is provided with a power switch (not shown), pairs of foot electrodes 11 and 12, a display 13 and a data input portion 14 on the top of the meter housing. In addition, a weight sensor and a control circuit having an arithmetic component are included inside the housing of weight meter 10.

[0028] Fig. 4 is a schematic block diagram representing a circuit configuration of the body fat measuring apparatus, as shown in Fig. 3. As shown in Fig. 4, the weight meter 10 includes a control circuit 1 as the main component within the housing, as usual. The control circuit 1 functions to receive a data from data input switches on the data input portion 14, and a weight data detected by the weight sensor. In addition, it receives data signals from constant current electrode plates and voltage measuring electrode plates of the pairs of foot electrodes 11 and 12, and a data from the skin hold caliper 40. Based on those data, the control circuit performs arithmetic operations, as described below, for indicating the results of the arithmetic operations on the display 13.

[0029] Similar to the embodiment as above, instead of the control circuit 1 and the data input switches 14 positioned on the weight meter 10, the similar control circuit 2 and the data input switches may be positioned on the skin hold caliper 40, as shown in Fig. 4. In addition, instead of the electric cable 20, the radio frequency communication or optical communication may be done for data transmission between transmitter / receiver portions in the weight meter 10 and the skin hold caliper 40, as indicated by a broken line in Fig. 4.

[0030] In both embodiments as described above, the weight meter 10 with the fat meter included therein is designed to perform measurement of the bioelectrical impedance between both feet of a person. The present invention is not necessarily be limited to such design, but it may be applied to such configuration that measurement is performed between both hands, between a hand and a foot, between both feet and a hand, as well as between both hands and both feet. The ultrasonic probe 30 functions to measure the thickness of subcutaneous fat in abdomen of a person. In this connection, the measurement may be performed either in "A-mode" which is simple and described latter in detail, or in "B-mode" which takes relatively higher cost. The body fat measuring apparatus in the embodiments as described above use the ultrasonic probe or the skin hold caliper to measure the thickness of subcutaneous fat.in abdomen of a person, but they may use other measuring means for performing the same measurement.

[0031] Now, a method for measuring a distribution of body fat for a person according to the present invention will be described, in association with the operation of the body fat measuring apparatus in the embodiments as described above.

[0032] Fig. 5 is a flow chart briefly representing the steps of measuring the distribution of body fat according to the present invention. Figs. 6 and 7 represent in more detail the steps as shown in Fig. 5 in the form of a flow chart. Referring to Figs. 5 to 7, a person who wants to measure his distribution of body fat turns on the body fat measuring apparatus, as shown in step 1 in Fig. 5. Then, in steps 2 to 4, he enters the personal data such as his height, age, sex, etc., into the apparatus via the data input switches on the data input portion 14. Then, in step 5, the person enters the weight of the clothes that he wears (or the tare weight). This step 5, however, may be bypassed.

[0033] Then, in step 6, the person measures the thickness of subcutaneous fat in his abdomen by using the ultrasonic probe 30 or the skin hold caliper 40. In this connection, the measurement of the thickness of subcutaneous fat in abdomen by the ultrasonic probe 30 is performed in "A-mode" of operation. The measurement data on the thickness of subcutaneous fat in abdomen obtained by the ultrasonic probe 30 or the skin hold caliper 40 is transmitted to the control circuit of the weight meter 10. With regard to "A-mode" of operation for measuring the thickness of subcutaneous fat, the ultrasonic probe 30 produces a high frequency ultrasonic signal that is incident on a surface of the body of the person. Then the ultrasonic signal is reflected from the boundary between a fatty fascia and a peritoneum or between the fatty fascia and a muscle fascia back to the probe 30. Then the time period between the transmission of the ultrasonic signal and the reception of the reflected ultrasonic signal is measured. The thickness of fatty fascia can be determined based upon the time period thus measured and the known velocity value of sound through the fatty fascia.

[0034] Then, the person mounts the weight meter 10 with soles of his feet positioned on the pairs of foot electrodes 11 and 12. In step 7, the weight sensor acts to measure the weight of the person, and the weight thus measured is transmitted to the control circuit 1. Then, in step 8, the bioelectrical impedance is measured. In this connection, the bioelectrical impedance is calculated, based upon the detection signals fed to the control circuit 1 from the constant current electrode plates and voltage measuring electrode plates of the foot electrode pairs 11 and 12.

[0035] In step 9, the total amount of fat is calculated from the bioelectrical impedance by the arithmetic circuit within the control circuit 1. The calculation of the total amount of fat is performed according to "BIA" process, for instance. In "BIA" process, the impedance between two parts (for instance, between both feet) of a person is measured, and thereafter, the rate of body fat is calculated by utilizing the fact that the relation between a fat tissue and a defatting tissue is closely related to the bioelectrical impedance. Then the rate of body fat is corrected with the personal data such as height, weight, age, etc.

[0036] Based upon the data entered as described above, the arithmetic circuit within the control circuit 1 performs a several operations as follows:

A. (1) Calculation of total area (or cross sectional area) of fat in abdomen:

[0037] The total area or amount of fat in abdomen is calculated in relation to the total amount of fat (see Fig. 9).

[0038] At present time, the distribution of fat for a human body is generally consisting of two types: subcutaneous fat and visceral fat (or fat in abdominal cavity). As is well known, the subcutaneous fat is mainly present in abdomen and the visceral fat is also present in the abdomen of a person. Therefore, both types of fats are concentrated in the abdomen of a person. Assuming that the sum of both types of fat is considered as the total amount of fat, the total amount of fat is strongly related to the total area or amount of fat in abdomen. Fig. 9 shows the correlation between the total amount of fat and the total area of fat in abdomen. Due to the correlation present therebetween, a regression curve can be used to determine the total area or amount of fat in abdomen from the total amount of fat.

[0039] Before the detailed description with reference to Figs. 9 to 25, some terms such as Correlation Factor "r", Risk Factor "p<z" and Regression Curve are defined as follows:

[0040] As for the correlation factor "r", as this factor "r" approaches "1", any deviation from the regression curve becomes small and the function consisting of both variables "X" and "Y" becomes sensitive. In other words, there is no such possibility present that the change in amount of "Y" becomes unduly greater in relation to the change in amount of "X".

[0041] As for the risk factor "p<z", the percentage for which there is no correlation is less than the value of z*100(%).

[0042] As for the regression curve, it is represented by the following formula:

$$Y = a \cdot X + b$$

Where "Y" is derived based upon the value "X"; a horizontal axis in the graph represents "X", a vertical axis represents "Y"; and the coefficients "a" and "b" are calculated using the actual measurement values as follows:

$$b = \{\Sigma(X\text{-}X[\text{average}]) \cdot (Y\text{-}Y[\text{average}])\}/\Sigma\{X\text{-}X[\text{average}]^2\}$$

$$a = Y[\text{average}]\text{-}b \cdot X[\text{average}]$$

A. (2) Calculation of an area (or cross sectional area) of subcutaneous fat in abdomen:

[0043] The area or amount of subcutaneous fat in abdomen is calculated in relation to the thickness of abdominal subcutaneous fat, or the product of thickness of abdominal subcutaneous fat and waist size (see Fig. 10 or 16). In the latter case, it is required that the girth of waist is measured in step 7' between steps 6 and 7 in Fig. 5.

[0044] Referring to Fig. 8, assuming that the abdomen is a true circle in shape, the area (or cross sectional area) of subcutaneous fat in the abdomen is calculated as follows:

$$\text{Radius of abdomen} = \text{waist size} / (2\ \pi)$$

$$\text{Area of subcutaneous fat} = (\text{radius of abdomen})^2 \times \pi - (\text{radius of abdomen - thickness of abdominal subcutaneous fat})^2 \times \pi$$

Because the thickness of abdominal subcutaneous fat is extremely small, as compared to the girth of abdomen (or waist size), the area of abdominal subcutaneous fat can be expressed as follows:

$$\text{Area of abdominal subcutaneous fat} \fallingdotseq (\text{thickness of abdominal subcutaneous fat} \times \text{waist size})$$

Fig. 16 shows the correlation between the estimated area and the actually measured area of said abdominal subcutaneous fat (the horizontal axis in the graph represents the estimated value which equals the product of waist size and thickness of abdominal subcutaneous fat). As the result, due to the fact that the actual human body is not a true circle in cross sectional shape, there may be some difference between the actual measured values and the estimated values. However, the regression curve appears substantially linear, and therefore, it is possible to estimate the area or amount of abdominal subcutaneous fat simply by measuring the waist size and the thickness of subcutaneous fat. Fig. 10 shows the correlation between the actually measured values of thickness and area of abdominal subcutaneous fat, that is effective to make the measuring process more easy. As the result, due to the correlation present therebetween, the regression curve can be used for estimating the area or amount of abdominal subcutaneous fat from the thickness of abdominal subcutaneous fat.

A. (3) Calculation of an area of abdominal visceral fat / an area of abdominal subcutaneous fat:

[0045] The area or amount of abdominal visceral fat is calculated by subtracting the area or amount of abdominal subcutaneous fat from the total area or mount of fat in abdomen. Then, the area or amount of abdominal visceral fat / the area or amount of abdominal subcutaneous fat is calculated.

B. (1) Calculation of an area of abdominal visceral fat:

[0046] The area or amount of abdominal visceral fat is calculated in relation to the total amount of fat (see Fig. 11).

B. (2) Calculation of an area of abdominal subcutaneous fat:

[0047] The area or amount of abdominal subcutaneous fat is calculated in relation to the thickness of subcutaneous fat, or the product of thickness of abdominal subcutaneous fat and waist size (see Fig. 10 or 16). Refer to description for item A. (2) above.

B. (3) Calculation of an area of abdominal visceral fat / an area of abdominal subcutaneous fat:

C. (1) Calculation of total amount of subcutaneous fat:

[0048] The total amount of subcutaneous fat is calculated in relation to the thickness of subcutaneous fat, or the product of thickness of subcutaneous fat and weight $^{0.425}$ and height $^{0.725}$ (see Fig. 12 or 15).

[0049] Several formulas for deriving the body surface area have been published, one of which is described below:

$$\text{Total body surface area (cm}^2\text{) = weight (kg)}^{0.425} \times \text{height(cm)}^{0.725} \times 70.98$$

The rate of body surface area of a main body and limbs relative to the total body surface area is generally considered as about 80%. Then the following formula is resulted:

$$\text{Body surface area of a main body and limbs (cm}^2\text{) =}$$

$$\text{total body surface area (cm}^2\text{)} \times 0.8$$

The thickness of subcutaneous fat in several parts of the body (for instance, thigh, crural, abdomen, flank, upper arm, etc.) is measured and the average of them is determined. Due to the fact that density of fat is 0.9g/cm^2, the total amount of subcutaneous fat is calculated according to the following formula:

$$\text{Total amount of subcutaneous fat (g) = (body surface area of main}$$

$$\text{body and limbs)} \times \text{(average thickness of subcutaneous fat)} \times 0.9$$

This is the most theoretical formula, but for the sake of simplicity, the total amount of subcutaneous fat may be calculated simply by using the values of thickness of subcutaneous fat in less number of parts of the body.

[0050] The part of the body having the largest amount of subcutaneous fat is abdomen, and therefore, it must have the greatest contribution to the total amount of subcutaneous fat. Accordingly the average thickness of subcutaneous fat is substituted by the thickness of subcutaneous fat in abdomen to produce an estimate of the total amount of subcutaneous fat. Fig. 15 shows the correlation between such estimated values of total amount of subcutaneous fat and the actually measured values therefor.

[0051] As the result, it is apparent that the values are substantially present on a line. Therefore, it is possible to estimate the total amount of subcutaneous fat from the thickness of subcutaneous fat in abdomen.

[0052] Alternatively, more facilitated method of getting the total amount of subcutaneous fat is to obtain the correlation between the thickness of subcutaneous fat in abdomen and the total amount of subcutaneous fat. Then, the regression curve is used to estimate the total amount of subcutaneous fat from the thickness of subcutaneous fat. Fig. 12 shows the relation between the thickness of subcutaneous fat in abdomen and the total amount of subcutaneous fat. Due to the correlation present therebetween, it is possible to use the regression curve for estimating the total amount of subcutaneous fat from the thickness of subcutaneous fat.

C. (2) Calculation of an amount of visceral fat:

[0053] The amount of visceral fat is calculated by subtracting the amount of subcutaneous fat from the total amount of fat.

C. (3) Calculation of an area of abdominal subcutaneous fat:

[0054] The area of abdominal subcutaneous fat is calculated in relation to the thickness of abdominal subcutaneous fat or the total amount of subcutaneous fat or the product of thickness of subcutaneous fat and waist size (see Fig. 10 or 13 or 16). Refer to item A. (2) as above.

C. (4) Calculation of an area of abdominal visceral fat:

[0055] The area of abdominal visceral fat is calculated in relation to the amount of visceral fat (see Fig. 14).

[0056] It is apparent from the foregoing that the present invention provides a new and improved method and apparatus for producing a several information useful for health care of a person with great simplicity and lower cost and without any adverse effect to the human body. The information thus produced includes, not only data of a body fat, but also data regarding a distribution of fat, such as an area or amount of visceral fat, an area or amount of subcutaneous fat, an area of abdominal visceral fat, and an area of abdominal subcutaneous fat.

Claims

1. A method of measuring a distribution of body fat for human body, **characterised in that** it comprises the steps of:

measuring a bioelectrical impedance and a thickness of abdominal subcutaneous fat; and
calculating an area of abdominal visceral fat, and/or an area of abdominal subcutaneous fat or calculating an amount of abdominal visceral fat and/or an amount of abdominal subcutaneous fat based on the measurements of the bioelectrical impedance and the thickness of abdominal subcutaneous fat and on the personal data including at least one of sex, age, height and weight of a person.

2. A method according to claim 1 in which it further comprises the steps of:

measuring a girth of abdomen; and
calculating an area or amount of abdominal visceral or subcutaneous fat ***[deletion(s)]*** in said calculating step based on the measurements of the bioelectrical impedance, the thickness of abdominal subcutaneous fat and the girth of abdomen.

3. A method according to any one of claims 1 or 2 in which said thickness of abdominal subcutaneous fat is measured by using an ultrasonic signal or by using a skin hold caliper.

4. An apparatus for measuring a distribution of body fat for human body, **characterised in that** it comprises:

a first input unit that enters the personal data including at least one of sex, age, height and weight of a person;
a measuring unit that measures a bioelectrical impedance;
a second input unit that enters a thickness of abdominal subcutaneous fat; and
an arithmetic element that calculates an area of abdominal visceral fat and/or an area of abdominal subcutaneous fat or an arithmetic element that calculates an amount of abdominal visceral fat and/or an amount of abdominal subcutaneous fat based on the data from said first input unit, said measuring unit and said input unit.

5. An apparatus according to claim 4 in which it further comprises:

a third input unit that enters a girth of abdomen; and
an area or amount of abdominal visceral or subcutaneous fat is calculated by said arithmetic element, based on the data from said first input unit, said measuring unit, said second input unit and said third input unit.

6. An apparatus according to any one of claims 4 or 5 in which said second input unit includes an ultrasonic probe.

7. An apparatus according to claim 6 in which a radio communication means or an optical communication means is provided for transmitting the data detected by said ultrasonic probe to said arithmetic element.

8. An apparatus according to any one of claims 4 or 5 in which said second input unit includes a skin hold caliper.

9. An apparatus according to claim 8 in which a radio communication means or an optical communication means is provided for transmitting the data detected by said skin hold caliper to said arithmetic element.

Patentansprüche

1. Verfahren des Messens einer Verteilung von Körperfett für einen menschlichen Körper, **dadurch gekennzeichnet, daß** es die Schritte umfaßt:

   Messen einer bioelektrischen Impedanz und einer Dicke von abdominalem, subkutanem Fett; und
   Berechnen eines Bereichs bzw. einer Fläche von abdominalem, viszeralem Fett und/oder eines Bereichs bzw. einer Fläche von abdominalem, subkutanem Fett oder Berechnen einer Menge von abdominalem, viszeralem Fett und/oder einer Menge von abdominalem, subkutanem Fett basierend auf den Messungen der bioelektrischen Impedanz und der Dicke des abdominalen, subkutanen Fetts und auf den persönlichen bzw. Personendaten, umfassend bzw. beinhaltend wenigstens eines aus Geschlecht, Alter, Größe und Gewicht einer Person.

2. Verfahren nach Anspruch 1, welches weiters die Schritte umfaßt:

   Messen eines Umfangs des Abdomen; und
   Berechnen eines Bereichs oder einer Menge von abdominalem, viszeralem oder subkutanem Fett in dem Berechnungsschritt basierend auf den Messungen der bioelektrischen Impedanz der Dicke von abdominalem, subkutanem Fett und dem Umfang des Abdomens.

3. Verfahren nach einem der Ansprüche 1 oder 2, wobei die Dicke des abdominalen, subkutanen Fetts unter Verwendung eines Ultraschallsignals oder unter Verwendung eines Hauthaltegreifers bzw. -tasters gemessen wird.

4. Vorrichtung zum Messen einer Verteilung von Körperfett für einen menschlichen Körper, **dadurch gekennzeichnet, daß** sie umfaßt:

   eine erste Eingabeeinheit, welche die persönlichen bzw. Personendaten, umfassend bzw. beinhaltend wenigstens eines aus Geschlecht, Alter, Größe und Gewicht einer Person, eingibt;
   eine Meßeinheit, welche eine bioelektrische Impedanz mißt;
   eine zweite Eingabeeinheit, die eine Dicke von abdominalem, subkutanem Fett eingibt; und
   ein arithmetisches Element, welches einen Bereich bzw. Fläche von abdominalem, viszeralem Fett und/oder einem Bereich bzw. Fläche von abdominalem, subkutanem Fett berechnet, oder ein arithmetisches Element, welches eine Menge von abdominalem, viszeralem Fett und/oder einer Menge von abdominalem, subkutanem Fett basierend auf den Daten von der ersten Eingabeeinheit, der Meßeinheit und der Eingabeeinheit berechnet.

5. Vorrichtung nach Anspruch 4, welche weiters umfaßt:

   eine dritte Eingabeeinheit, welche einen Umfang des Abdomens eingibt; und
   wobei ein Bereich oder eine Menge von abdominalem, viszeralem oder subkutanem Fett durch das arithmetische Element basierend auf den Daten der ersten Eingabeeinheit, der Meßeinheit, der zweiten Eingabeeinheit und der dritten Eingabeeinheit berechnet wird.

6. Vorrichtung nach Anspruch 4 oder 5, in welcher die zweite Eingabeeinheit einen Ultraschallmeßkopf beinhaltet.

7. Vorrichtung nach Anspruch 6, in welcher Funk- bzw. Radiokommunikationsmittel oder optische Kommunikationsmittel vorgesehen sind zum Übertragen der Daten, die durch den Ultraschallmeßkopf detektiert sind, zu dem arithmetischen Element.

8. Vorrichtung nach Anspruch 4 oder 5, in welcher die zweite Eingabeeinheit einen Hauthaltegreifer bzw. -taster beinhaltet.

9. Vorrichtung nach Anspruch 8, in welcher Funk- bzw. Radiokommunikationsmittel oder optische Kommunikationsmittel vorgesehen sind zum Übertragen der Daten, die durch den Hauthaltegreifer detektiert sind, zu dem arithmetischen Element.

Revendications

1. Procédé de mesure d'une répartition de la graisse corporelle pour corps humain, **caractérisé en ce qu'**il comprend les étapes consistant à :

   mesurer une impédance bioélectrique et une épaisseur de graisse sous-cutanée abdominale ; et
   calculer une zone de graisse viscérale abdominale, et/ou une zone de graisse sous-cutanée abdominale ou calculer une quantité de graisse viscérale abdominale et/ou une quantité de graisse sous-cutanée abdominale sur la base des mesures de l'impédance bioélectrique et de l'épaisseur de graisse sous-cutanée abdominale et sur les données personnelles comprenant au moins un élément parmi le sexe, l'âge, la taille et le poids d'une personne.

2. Procédé selon la revendication 1 qui comprend en outre les étapes consistant à :

   mesurer un tour d'abdomen ; et
   calculer une zone ou une quantité de graisse sous-cutanée ou viscérale abdominale dans ladite étape de calcul sur la base des mesures de l'impédance bioélectrique, l'épaisseur de graisse sous-cutanée abdominale et le tour d'abdomen.

3. Procédé selon l'une quelconque des revendications 1 ou 2 dans lequel ladite épaisseur de graisse sous-cutanée abdominale est mesurée en utilisant un signal ultrasonique ou en utilisant un adipomètre.

4. Appareil destiné à mesurer une répartition, de la graisse corporelle pour corps humain, **caractérisé en ce qu'**il comprend :

   une première unité d'entrée qui entre les données personnelles comprenant au moins un élément parmi le sexe, l'âge, la taille et le poids d'une personne ;
   une unité de mesure qui mesure une impédance bioélectrique ;
   une deuxième unité d'entrée qui entre une épaisseur de graisse sous-cutanée abdominale ; et
   un élément arithmétique qui calcule une zone de graisse viscérale abdominale et/ou une zone de graisse sous-cutanée abdominale ou un élément arithmétique qui calcule une quantité de graisse viscérale abdominale et/ou une quantité de graisse sous-cutanée abdominale sur la base des données provenant de ladite première unité d'entrée, de ladite unité de mesure et de ladite deuxième unité d'entrée.

5. Appareil selon la revendication 4 qui comprend en outre :

   une troisième unité d'entrée qui entre un tour d'abdomen ; et
   le calcul d'une zone ou d'une quantité de graisse sous-cutanée ou viscérale abdominale par ledit élément arithmétique, sur la base des données provenant de ladite première unité d'entrée, de ladite unité de mesure, de ladite deuxième unité d'entrée et de ladite troisième unité d'entrée.

6. Appareil selon l'une quelconque des revendications 4 ou 5, dans lequel ladite deuxième unité d'entrée comprend une sonde ultrasonique.

7. Appareil selon la revendication 6, dans lequel un moyen de communication radio ou un moyen de communication optique est prévu pour transmettre les données détectées par ladite sonde ultrasonique audit élément arithmétique.

8. Appareil selon l'une quelconque des revendications 4 ou 5, dans lequel ladite deuxième unité d'entrée comprend un adipomètre.

9. Appareil selon la revendication 8, dans lequel un moyen de communication radio ou un moyen de communication optique est prévu pour transmettre les données détectées par ledit adipomètre audit élément arithmétique.

FIG. 1

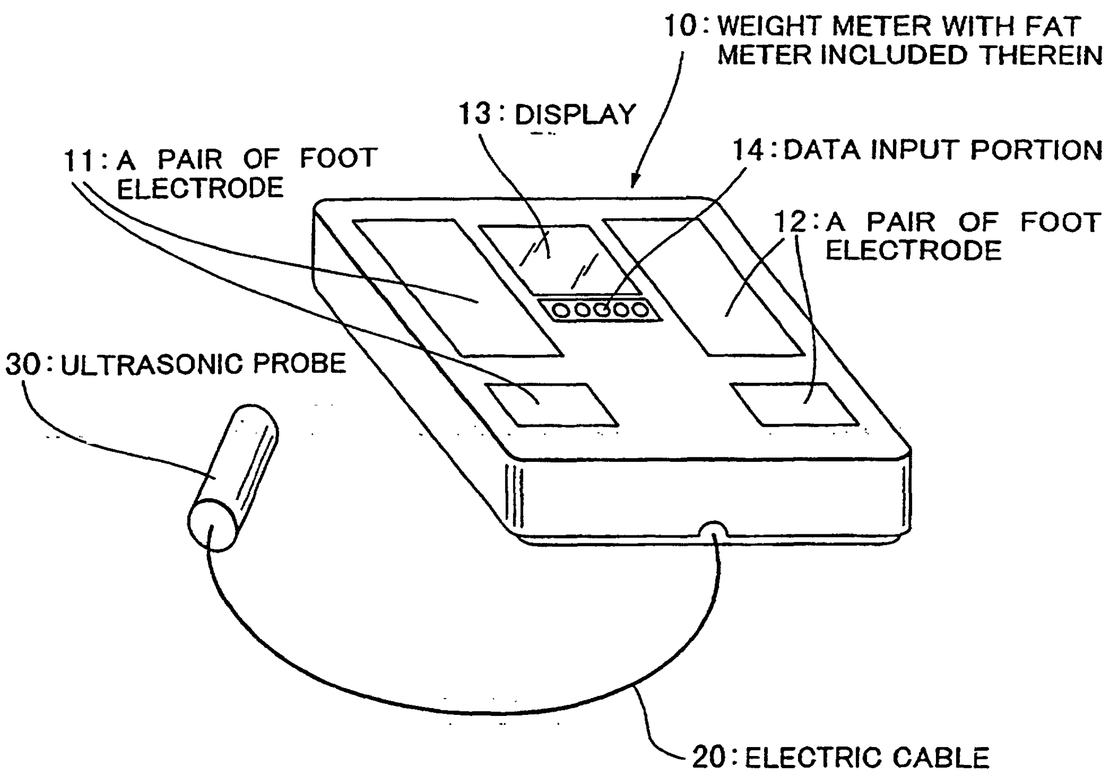

10: WEIGHT METER WITH FAT METER INCLUDED THEREIN
13: DISPLAY
11: A PAIR OF FOOT ELECTRODE
14: DATA INPUT PORTION
12: A PAIR OF FOOT ELECTRODE
30: ULTRASONIC PROBE
20: ELECTRIC CABLE

FIG. 2

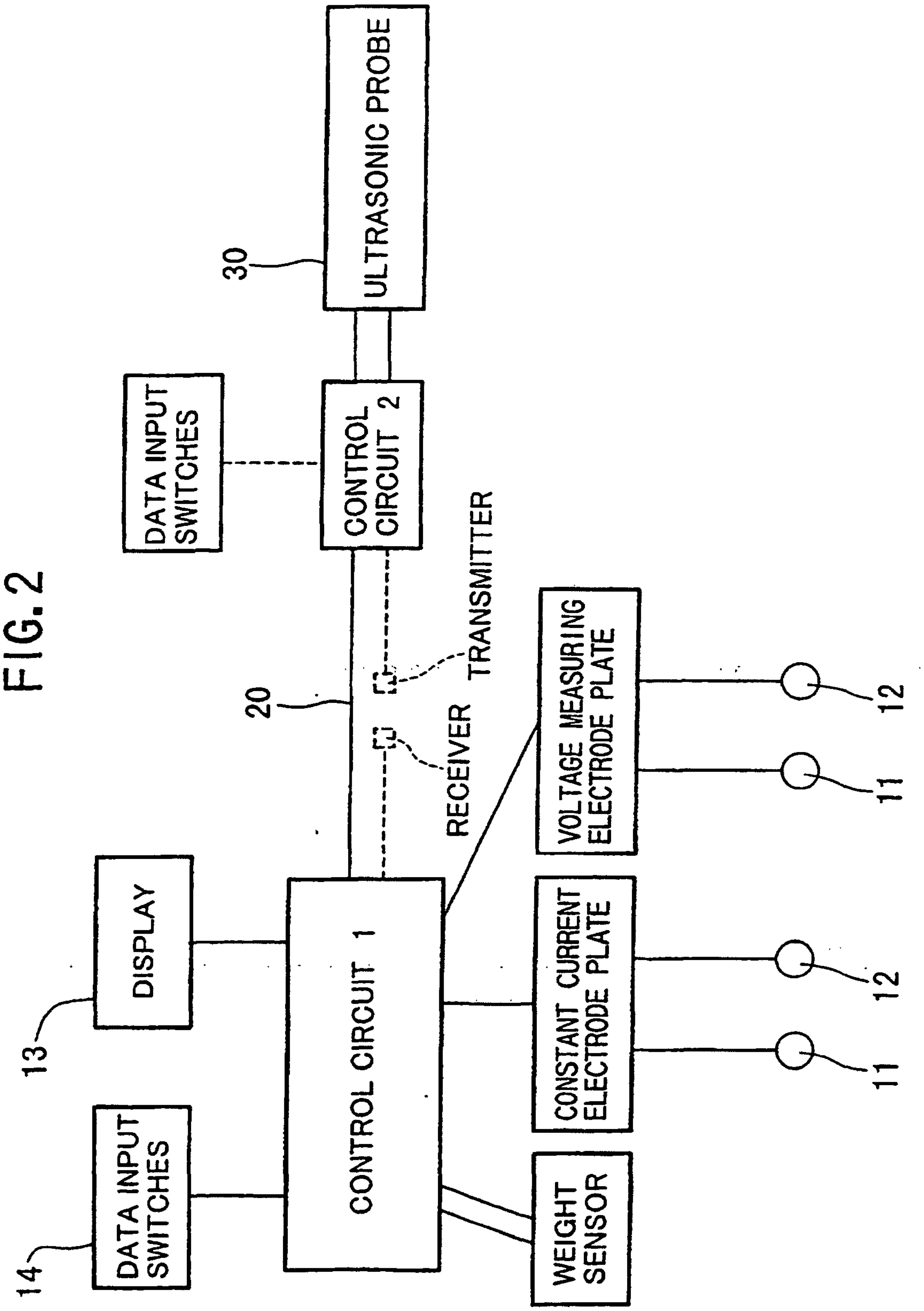

ULTRASONIC PROBE
30
DATA INPUT SWITCHES
CONTROL CIRCUIT 2
TRANSMITTER
20
RECEIVER
VOLTAGE MEASURING ELECTRODE PLATE
12
11
DISPLAY
13
CONTROL CIRCUIT 1
CONSTANT CURRENT ELECTRODE PLATE
12
11
DATA INPUT SWITCHES
14
WEIGHT SENSOR

FIG. 3

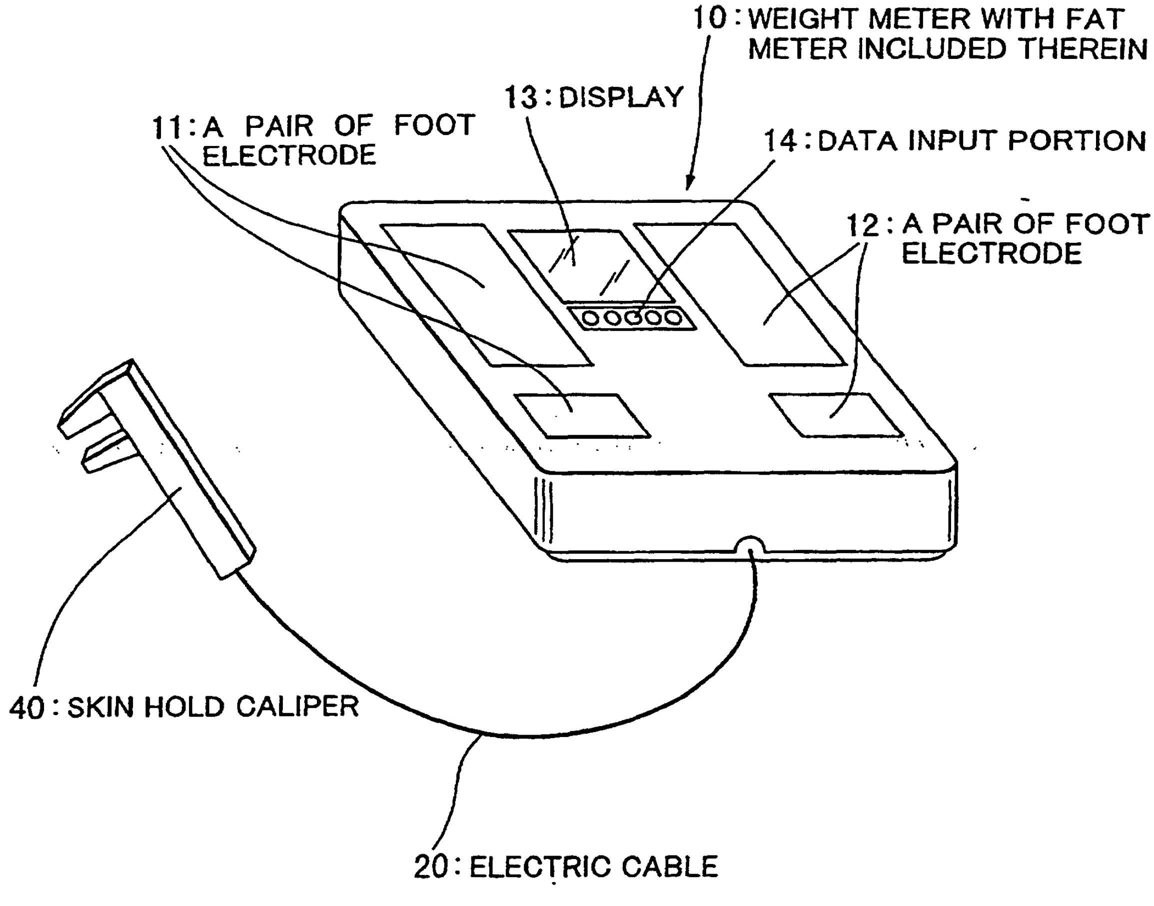

10: WEIGHT METER WITH FAT METER INCLUDED THEREIN
13: DISPLAY
11: A PAIR OF FOOT ELECTRODE
14: DATA INPUT PORTION
12: A PAIR OF FOOT ELECTRODE
40: SKIN HOLD CALIPER
20: ELECTRIC CABLE

FIG. 4

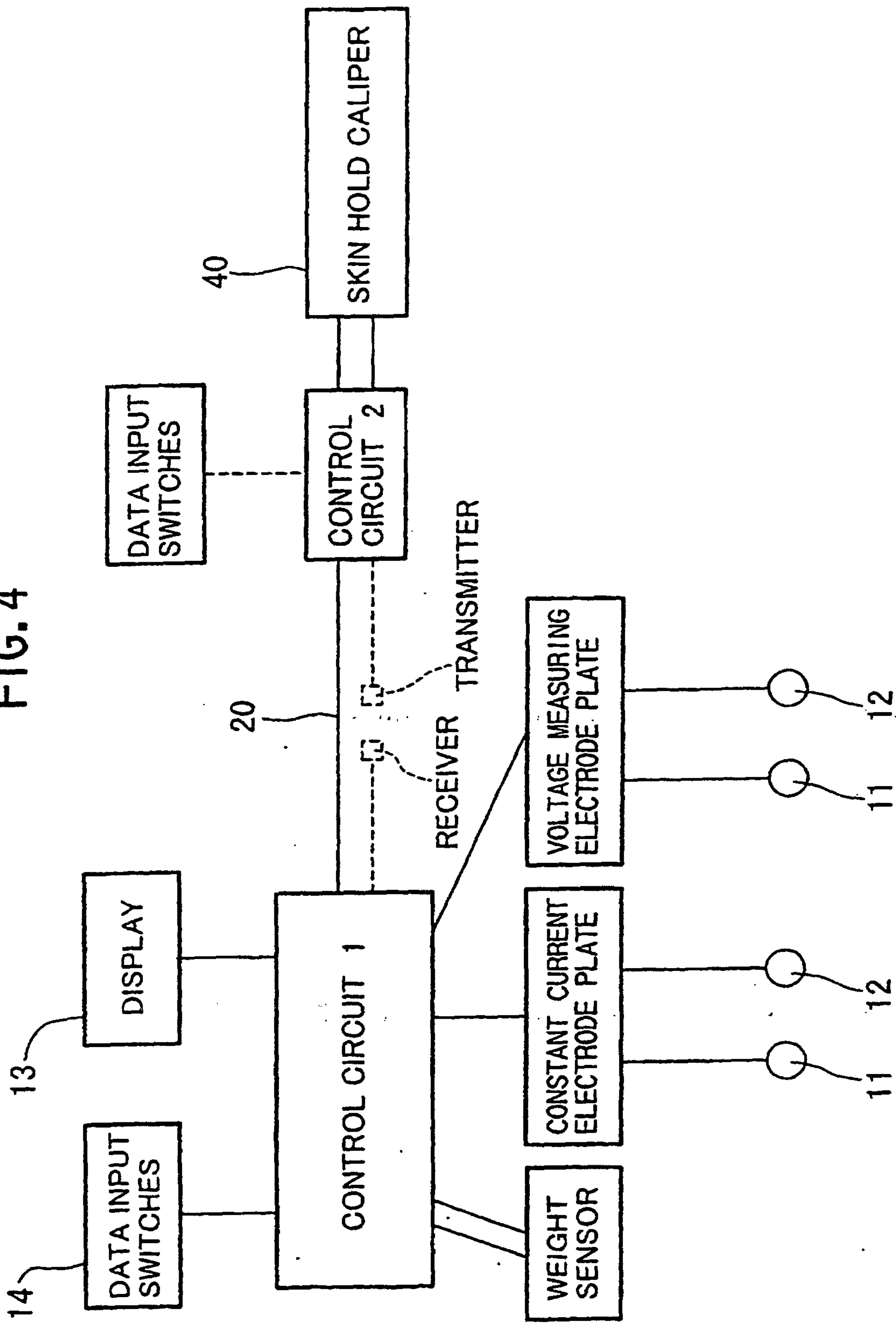

SKIN HOLD CALIPER
40
DATA INPUT SWITCHES
CONTROL CIRCUIT 2
TRANSMITTER
20
RECEIVER
VOLTAGE MEASURING ELECTRODE PLATE
12
11
DISPLAY
13
CONTROL CIRCUIT 1
CONSTANT CURRENT ELECTRODE PLATE
12
11
DATA INPUT SWITCHES
14
WEIGHT SENSOR

FIG. 5

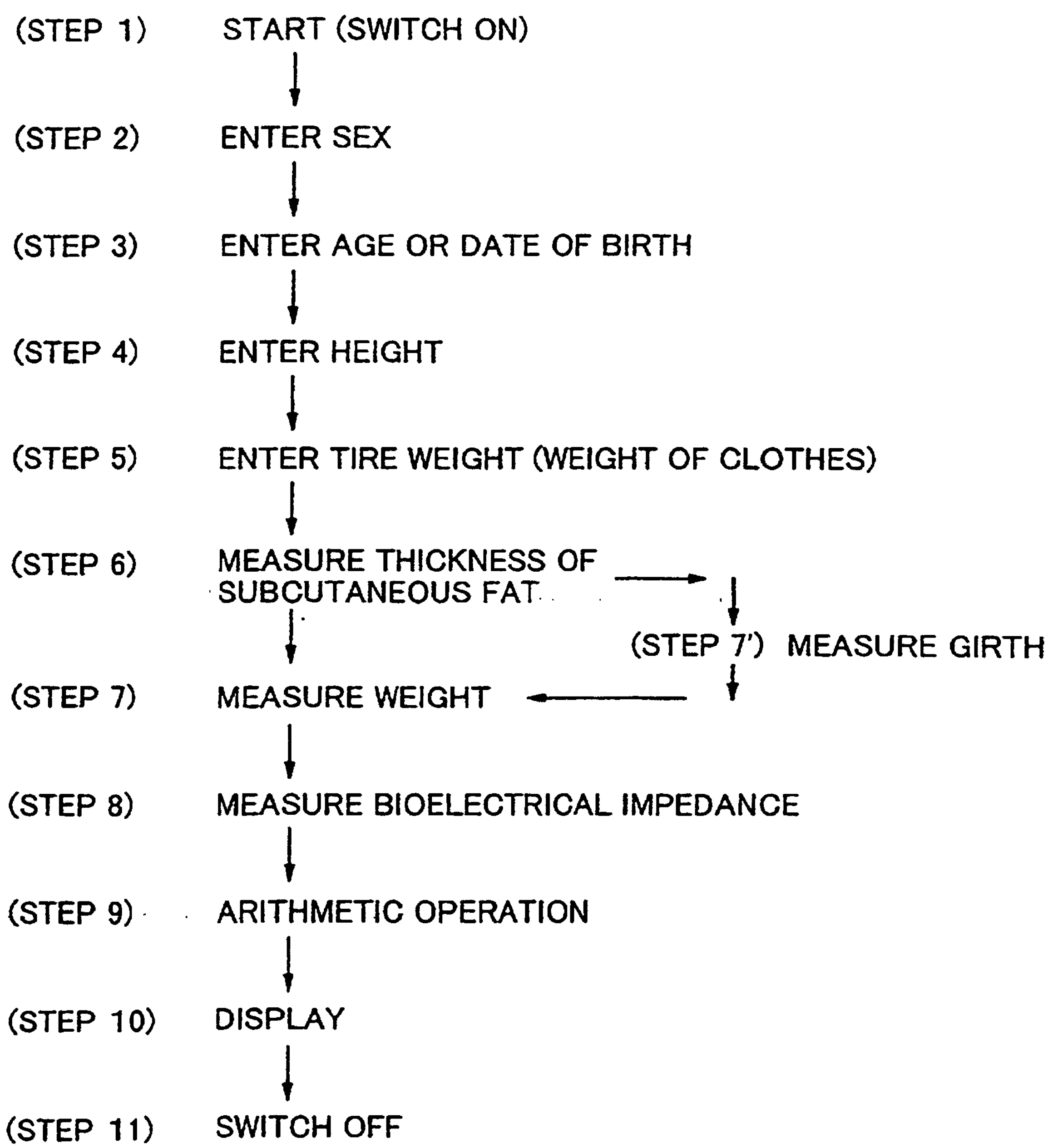

(STEP 1) START (SWITCH ON)
(STEP 2) ENTER SEX
(STEP 3) ENTER AGE OR DATE OF BIRTH
(STEP 4) ENTER HEIGHT
(STEP 5) ENTER TIRE WEIGHT (WEIGHT OF CLOTHES)
(STEP 6) MEASURE THICKNESS OF SUBCUTANEOUS FAT
(STEP 7') MEASURE GIRTH
(STEP 7) MEASURE WEIGHT
(STEP 8) MEASURE BIOELECTRICAL IMPEDANCE
(STEP 9) ARITHMETIC OPERATION
(STEP 10) DISPLAY
(STEP 11) SWITCH OFF

FIG.6

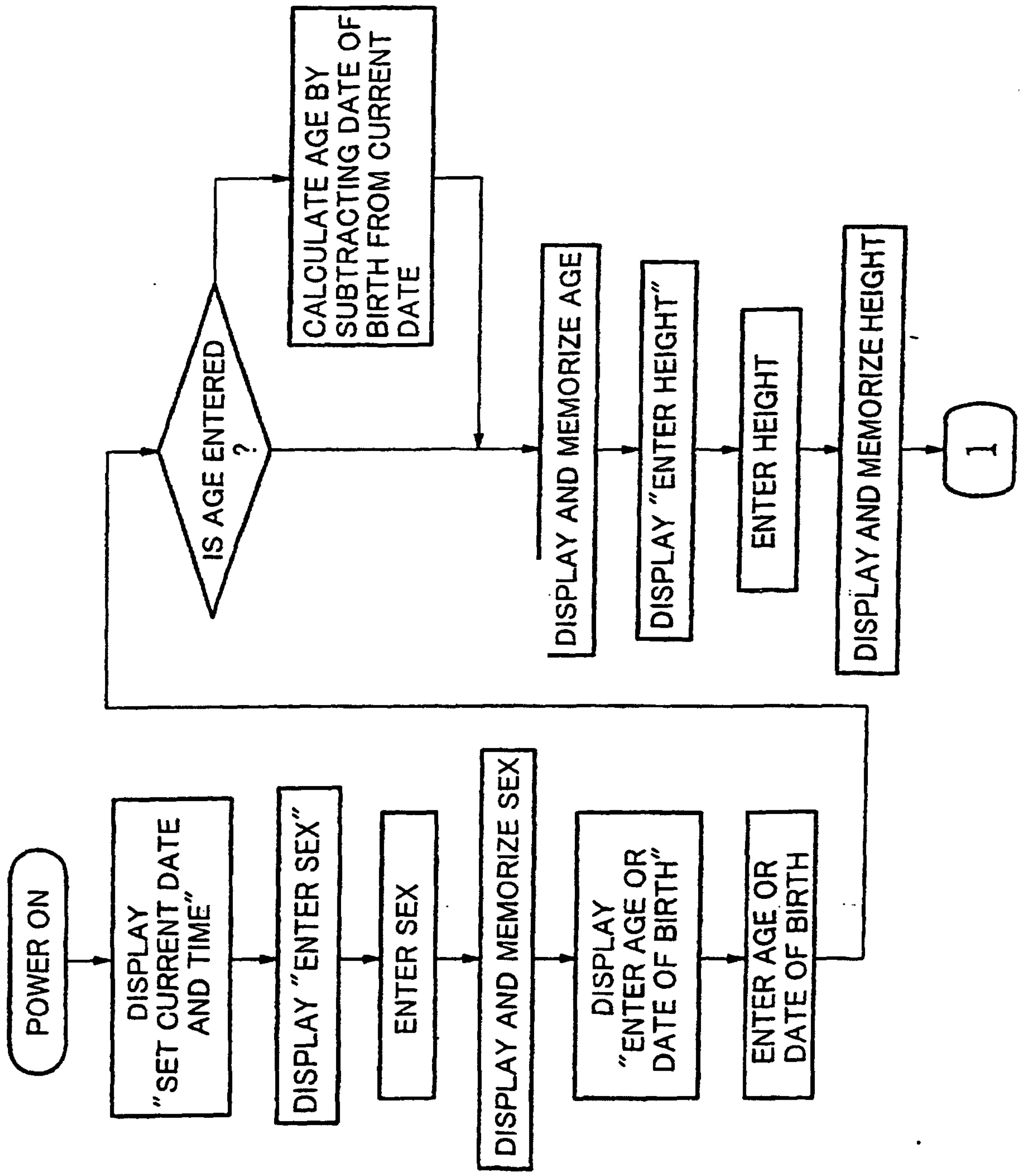

POWER ON
DISPLAY "SET CURRENT DATE AND TIME"
DISPLAY "ENTER SEX"
ENTER SEX
DISPLAY AND MEMORIZE SEX
DISPLAY "ENTER AGE OR DATE OF BIRTH"
ENTER AGE OR DATE OF BIRTH
IS AGE ENTERED ?
CALCULATE AGE BY SUBTRACTING DATE OF BIRTH FROM CURRENT DATE
DISPLAY AND MEMORIZE AGE
DISPLAY "ENTER HEIGHT"
ENTER HEIGHT
DISPLAY AND MEMORIZE HEIGHT
1

FIG. 7

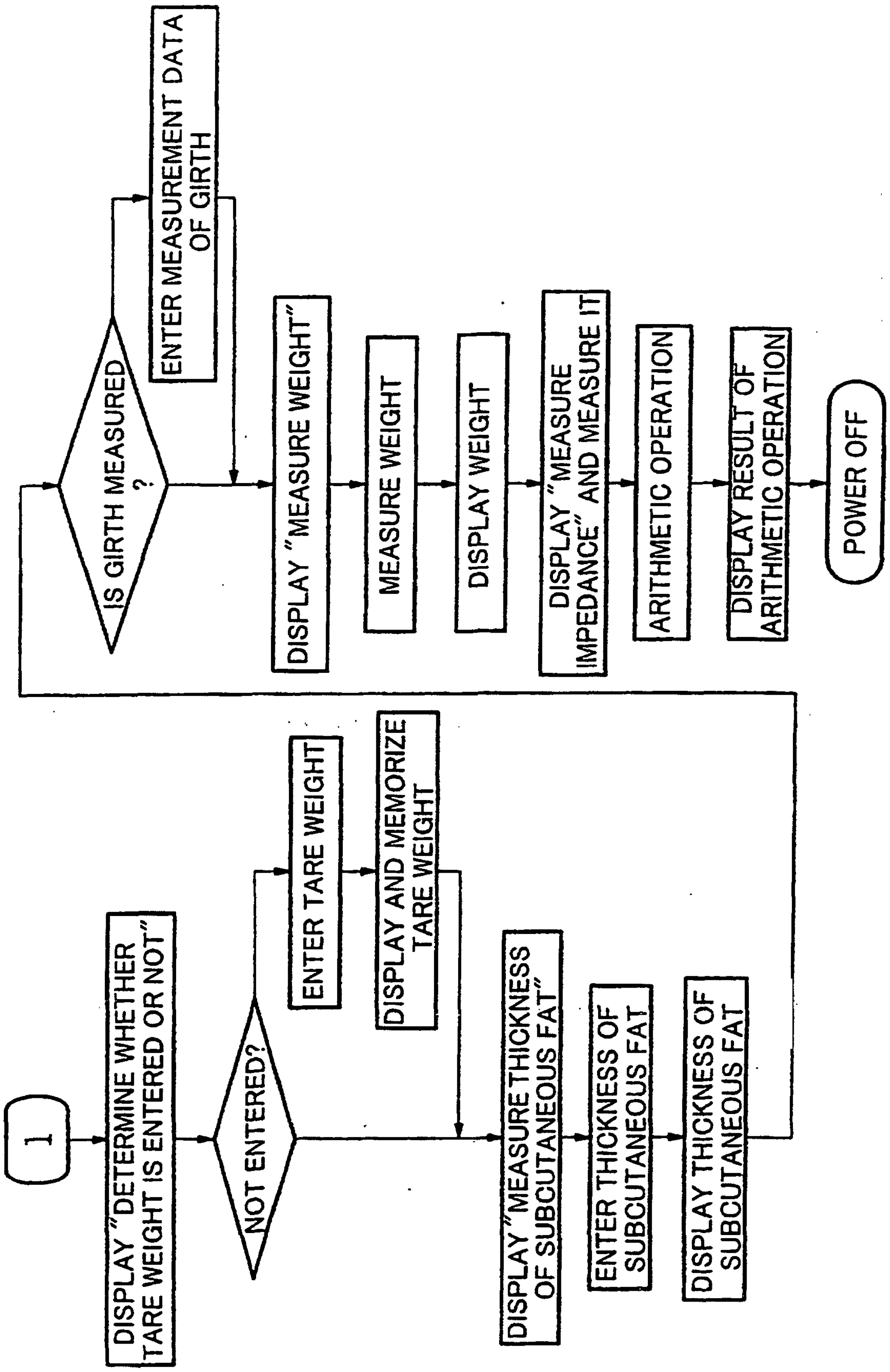

1
DISPLAY "DETERMINE WHETHER TARE WEIGHT IS ENTERED OR NOT"
NOT ENTERED?
ENTER TARE WEIGHT
DISPLAY AND MEMORIZE TARE WEIGHT
DISPLAY "MEASURE THICKNESS OF SUBCUTANEOUS FAT"
ENTER THICKNESS OF SUBCUTANEOUS FAT
DISPLAY THICKNESS OF SUBCUTANEOUS FAT
IS GIRTH MEASURED ?
ENTER MEASUREMENT DATA OF GIRTH
DISPLAY "MEASURE WEIGHT"
MEASURE WEIGHT
DISPLAY WEIGHT
DISPLAY "MEASURE IMPEDANCE" AND MEASURE IT
ARITHMETIC OPERATION
DISPLAY RESULT OF ARITHMETIC OPERATION
POWER OFF

FIG. 8

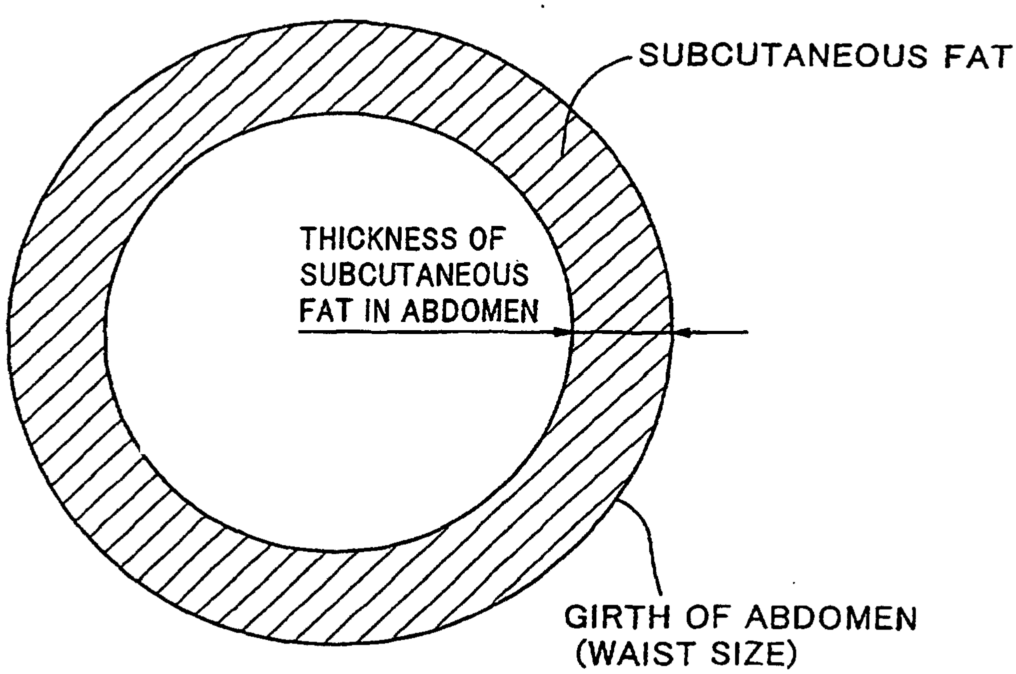

SUBCUTANEOUS FAT
THICKNESS OF SUBCUTANEOUS FAT IN ABDOMEN
GIRTH OF ABDOMEN (WAIST SIZE)

FIG. 9

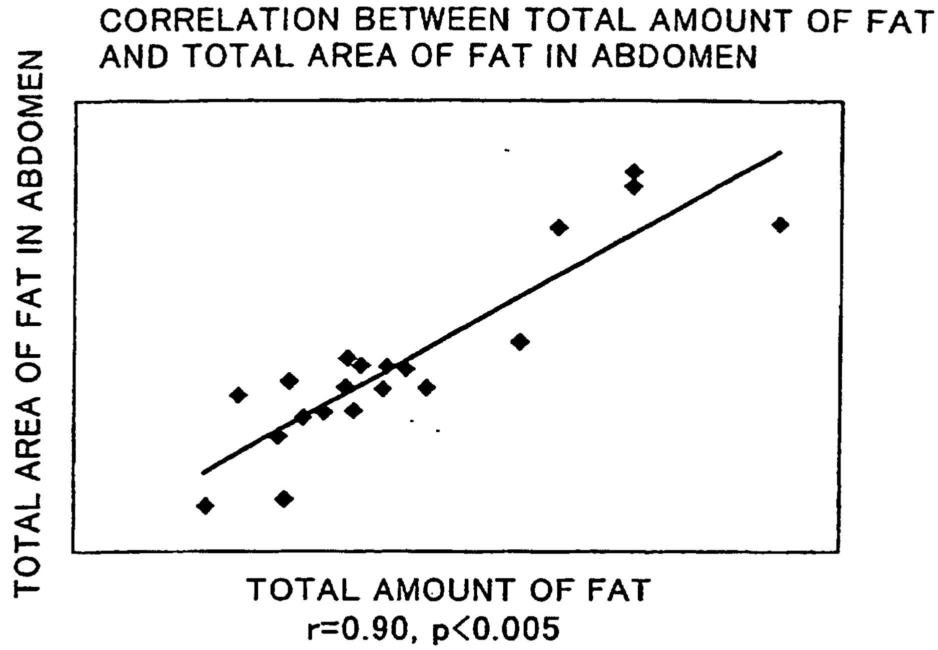

CORRELATION BETWEEN TOTAL AMOUNT OF FAT AND TOTAL AREA OF FAT IN ABDOMEN
TOTAL AREA OF FAT IN ABDOMEN
TOTAL AMOUNT OF FAT
r=0.90, p<0.005

FIG. 10

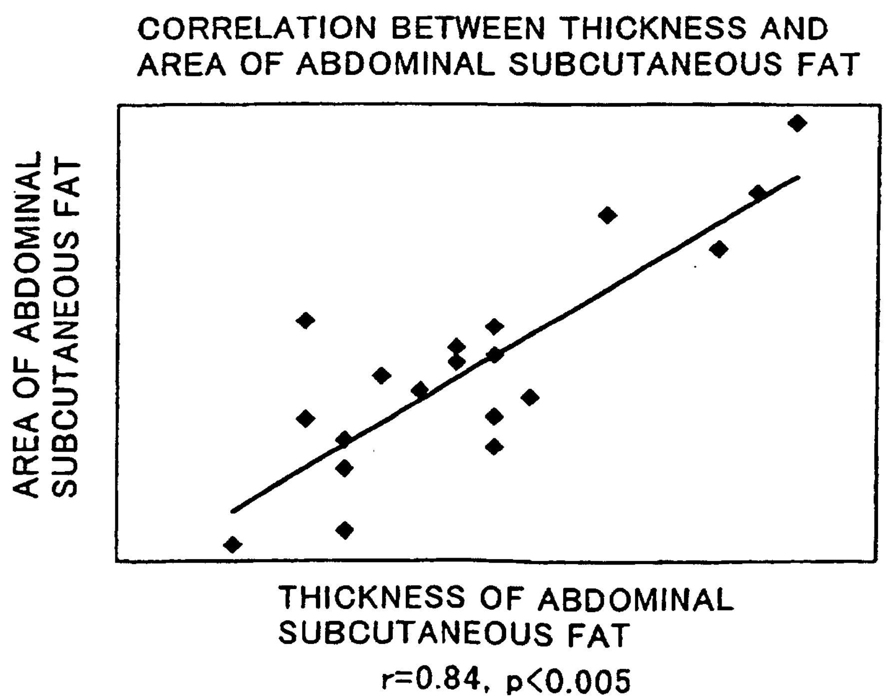
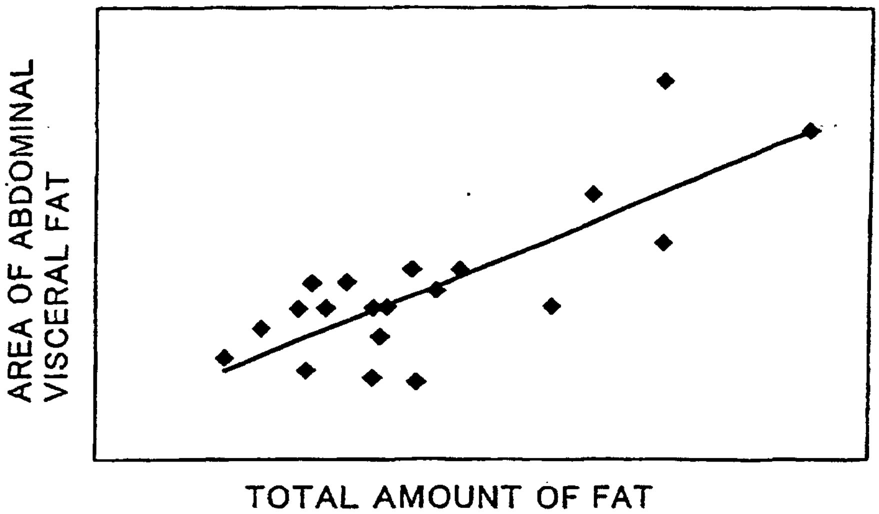

CORRELATION BETWEEN THICKNESS AND AREA OF ABDOMINAL SUBCUTANEOUS FAT
AREA OF ABDOMINAL SUBCUTANEOUS FAT
THICKNESS OF ABDOMINAL SUBCUTANEOUS FAT
r=0.84, p<0.005

FIG. 11

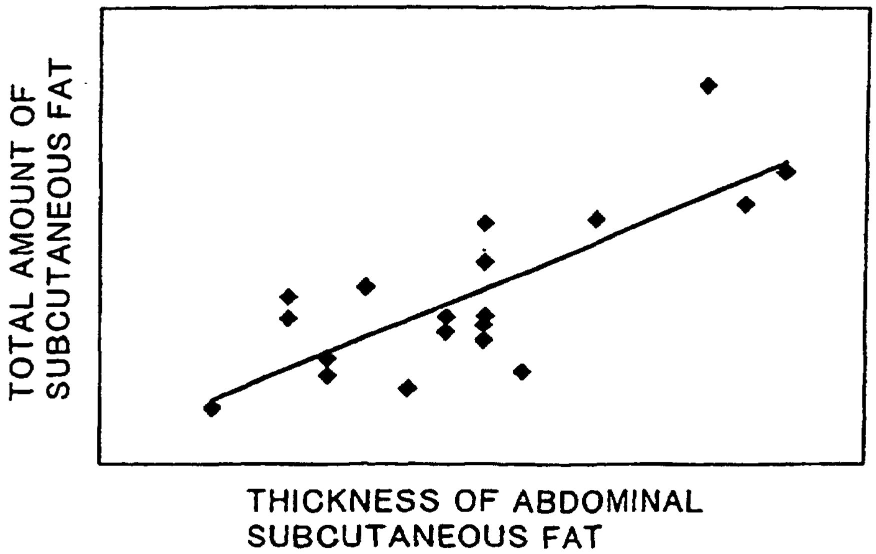
CORRELATION BETWEEN TOTAL AMOUNT OF FAT AND AREA OF ABDOMINAL VISCERAL FAT



r=0.79, p<0.005

FIG. 12

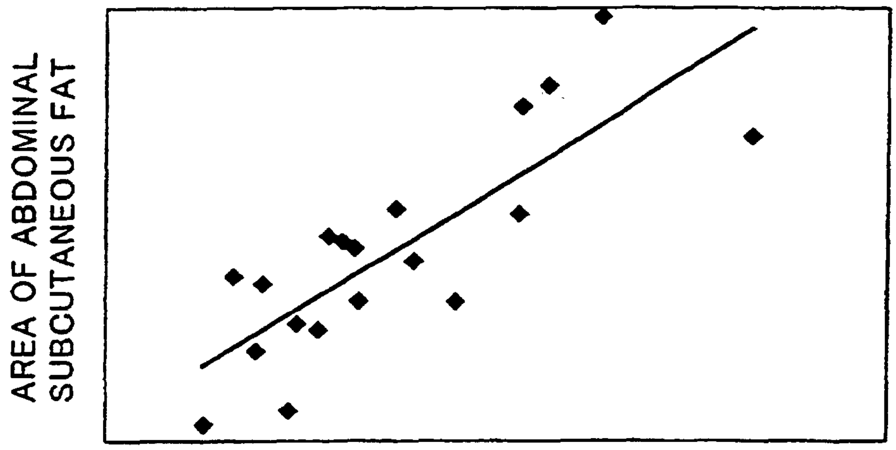
CORRELATION BETWEEN THICKNESS OF ABDOMINAI SUBCUTANEOUS FAT AND TOTAL AMOUNT OF SUBCUTANEOUS FAT



r=0.78, p<0.005

FIG. 13

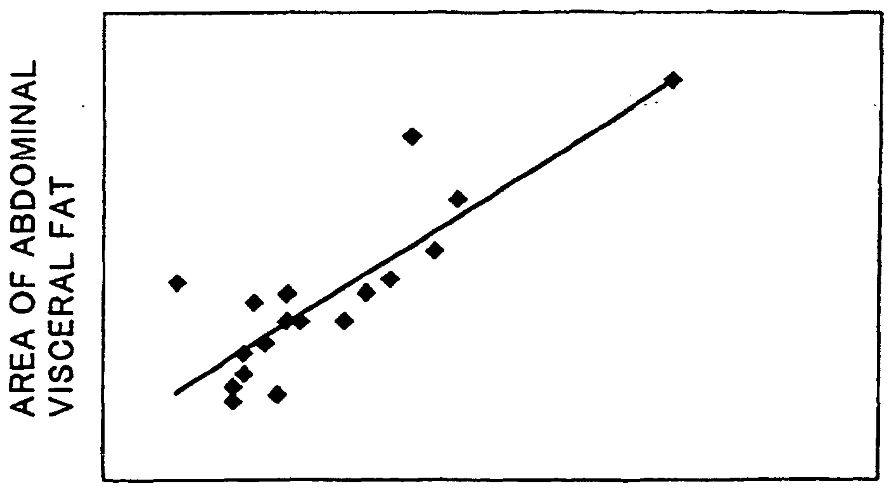
CORRELATION BETWEEN TOTAL SUBCUTANEOUS FAT AND AREA OF ABDOMINAL SUBCUTANEOUS FAT



TOTAL SUBCUTANEOUS FAT
r=0.80, p<0.005

FIG. 14

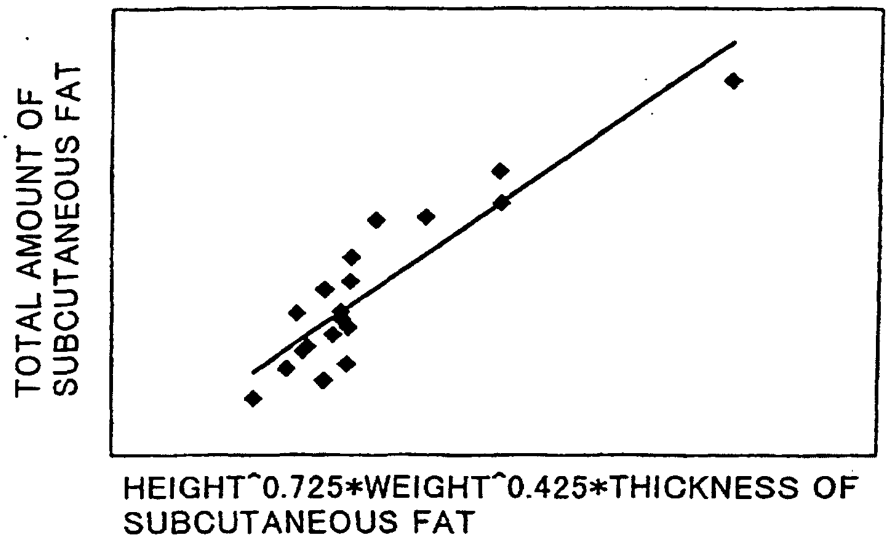
CORRELATION BETWEEN AMOUNT OF VISCERAL FAT AND AREA OF ABDOMINAL VISCERAL FAT



AMOUNT OF VISCERAL FAT
r=0.83, p<0.005

FIG. 15

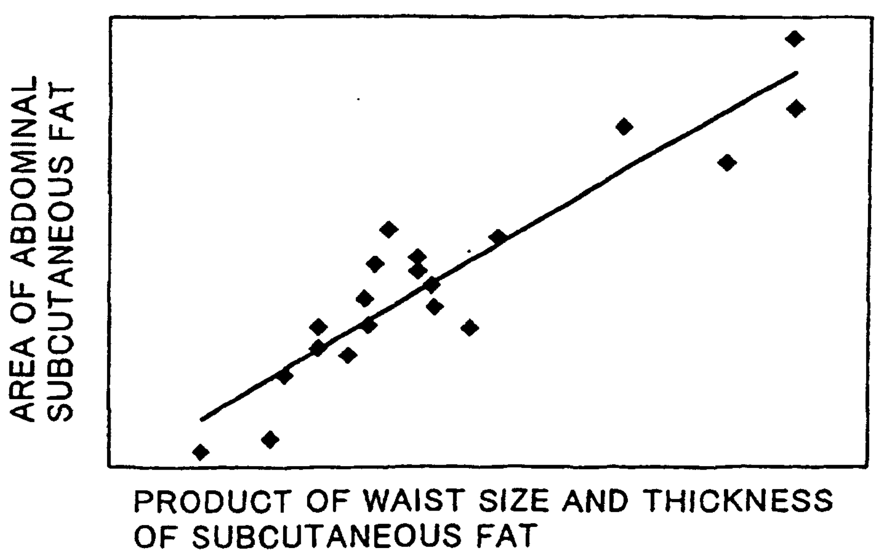
CORRELATION BETWEEN HEIGHT、WEIGHT AND THICKNESS OF SUBCUTANEOUS FAT、AND TOTAL AMOUNT OF SUBCUTANEOUS FAT



$r=0.90$, $p<0.005$

FIG. 16

CORRELATION BETWEEN PRODUCT OF WAIST SIZE AND THICKNESS OF SUBCUTANEOUS FAT、AND AREA OF ABDOMINAL SUBCUTANEOUS FAT



$r=0.93$, $p<0.005$