Provisional Patent Application of

Costas Stephanis
Yannis Hatiris
Dimitris Mourmouras
Christos Manavopoulos

for

Device and method for determining the density of human body, the absolute amount of fat and water as well as fat and water loss in humans resulting from a diet and/or exercise regime.

BACKGROUND OF THE INVENTION

Technical Field of the Invention

This invention relates to medical instruments for measuring absolute mass of fat as well as mass variations of fat and water in humans. Specifically, the invention relates to such instruments that determine content and content variations of fat and water in humans.

Description of Prior Art

Lately, the measurement of density has been internationally accepted and applied in methods for determining the composition and variations in fat, muscle, bone and water mass of the human body. The accuracy of related devices has been improved continuously with time, the latest achievement being the "Barrel of Ulm" described extensively in the Ph D dissertation of Hannelore Wenzerr published in October 1995 by Ulm University in Germany as ISBN3-89559-061-4 and used as a reference in the specification of the present invention.

Of remarkable perfection, the "Barrel of Ulm" uses, in common with previously proposed devices of inferior quality, the principle of Archimedes. The device includes a large tank of water, weighing a few tons, for measuring the displacement of the immersed subject under examination. This presents a number of disadvantages, some of them being as follows:

1. Going in and out of the tank is not an easy task because the subject, as a rule, is not an athletic type and because said subject is immersed in water to the neck.

2. The precision of measurements is influenced by the following facts:
   (a) The pressure of gases in the peptic system is different from the head internal pressure by as much as 50 cm of water column or 0.05 at.
   (b) The difference in relative humidity of the air surrounding the head and the water surrounding the rest of the body of the subject under examination.
   (c) The solubility in water of the exhaled by the subject CO_2.
   (d) The body of the subject absorbs water by osmosis.
   (e) The measurement of the weight of the subject is influenced by the buoyancy of the body in air that could be as high as 1.2 gr per liter of body volume or 100 – 150 gr for 83 – 125 liters of body volume.

   An existing method for determining the proportion of fat and water in the human body uses X rays with the well known disadvantages of harmful radiation. In addition to this, the precision is lower than the precision of the present invention.

The Utility Model GR 2001789 presented by G. Contos, D. Mourmouras, C. Stephanis, Y. Hatiris describes a device for determining fat and water variations in the human body during a diet. The device is limited by the following disadvantage:
The amount of air introduced in the container is constant for every measurement performed. Since the volume displacement for every subject varies, the internal pressure of the container will vary as well. This results in distortions of the shape of the container walls, so that variations in the volume of the container are unavoidable, therefore errors are introduced in the performed measurements. For extreme cases of voluminous subjects, the errors can become forbidding in accuracy by the fact that the inventors, in their effort to design an inexpensive device, have proposed a thin plastic material for building the container such as Plexiglas.

The problem of said distortion of the chamber is solved in the patent A61B5/107,G01F17/00 by G. Contos, D. Mourmouras, C. Stephanis, J. Hatiris as a follow up to Utility Model GR2001789. The disadvantage of this device and method was that it could only determine variations of fat and water resulting from changes in the total mass of the body resulting from a period of dietary regime.

From the above, the need for a device and method for determining the proportion along with absolute values of fat and water in the human body with high precision continues to exist.

Objects and Advantages

(a) Simple, safe and inexpensive device and method for determining absolute values of fat and water mass in addition to variations in fat and water mass of living organisms.

(b) Duration of measurement to last only a few seconds.

MAIN EMBODIMENT OF THE INVENTION

List of Drawing Figures

Fig 1. shows the chamber with the subject under examination.

Fig 2. shows the case of measuring the volume of a body having an open cavity whereby the volume of air contained in the cavity is excluded from the measurement.

Reference Symbols In Drawings

V_a is the additional volume of air pumped in the chamber
V_b is the volume of the subject to be examined
V_c is the volume of the chamber
v is the pressure equalization valve
p is the piston
m is the differential manometer
c is the cylinder containing air to be pumped into the chamber

Description of the Invention

The device consists of (a) a transparent, hermetically sealable chamber of fixed volume V_c for enclosing a subject under examination, said chamber communicating with an additional small cylindrical chamber c of volume V_a adjustable by piston p; a differential manometer m for measuring the difference in pressure between the interior of the chamber and the atmospheric; (c) a valve v for equalizing the internal pressure of the chamber with the atmospheric as well as for hermetically sealing the chamber.

Operation of the Invention

The method comprises the steps of:

1. Determining the volume of the body V_b without the cavities containing gases, that is, excluding the volume of gases in the respiratory and the peptic system. For this purpose, we calculate the volume of the air V_c in the empty chamber as follows:

(a) We open valve v in order to equalize the pressure in chamber with atmospheric.
(b) We close valve v and pump a predetermined air volume V_a into the chamber.

As a result of (a) and (b) we have (Boyle - Mariotte):

$$P_o (V_c + V_a) = P_1 V_c \quad \text{or} \quad V_c = P_o V_a / (P_1 - P_o)$$

(c) We repeat the procedure (a) and (b) with the body inside the chamber, as shown in Fig1 whereby we obtain the volume of the body V_b from the equivalent relation:

$$V_c - V_b = P_o V_a / (P_2 - P_o)$$

Note 1: For simplicity of reciting this summary, it is assumed that the chamber is absolutely rigid, therefore the volume V_c stays constant when internal pressure is increased by the additional volume of air V_a. The problem of the actual change in volume of the chamber is solved with a very simple workaround. The volume of the chamber is determined under the same internal pressure conditions in order to obtain the same distortion or change in volume. Therefore, the volume of the chamber, with and without the subject in the chamber, remains constant.

Note 2: The differences $(P_1 - P_o)$ and $(P_2 - P_o)$ are measured by the differential manometer m, for higher precision.
Note 3: When measuring the volume of a body with an open cavity, the volume of air contained in the cavity is excluded from the measurement as shown in Fig 2. In the respiratory system the pressure of gases in all cavities is equal to the pressure in the chamber while the volume of gases inhaled is equal to the volume of gases exhaled. The same can be proven for a closed cavity containing gases with equal to the chamber pressure. As a matter of fact, in the peptic system, the pressure of gases in the intestinal tract is practically equal to the pressure of the air in the environment.

2. Measuring the mass of the body, taking into consideration air buoyancy.

3. Determining the mean value density of the body from the mass and volume.

4. Determining the absolute content in fat using the mean value density D_m of the body and the linear relation $D_m = 1.1 - 0.00217X$, where X is the percentage of fat (from 0 to 60) derived from tables of statistical measurements performed at the University of Ulm in Germany for people of various ages, heights and weights.

5. Determining the relative content in fat by using the fat density $D_f = 0.900$ gr/cc and the water density $D_w = 1.000$ gr/cc of an isotonic solution at 37 degrees C, and assuming that the mass and volume of the rest of the body does not change (constant density of bones and muscles) from one measurement to another. We obtain the mass loss of fat and water from the system:

$$(M_t - M_t') = D_f (V_f - V_f') + D_w (V_w - V_w') \qquad (1)$$

$$(V_t - V_t') = (V_f - V_f') + (V_w - V_w') \qquad (2)$$

where M_t, V_t, V_f, V_w are the total mass of the body, the total volume of the body, the volume of fat and the volume of water before the diet/exercise regime and M_t', V_t', V_f', V_w' are the total mass of the body, the total volume of the body, the volume of fat and the volume of water after said regime. Since

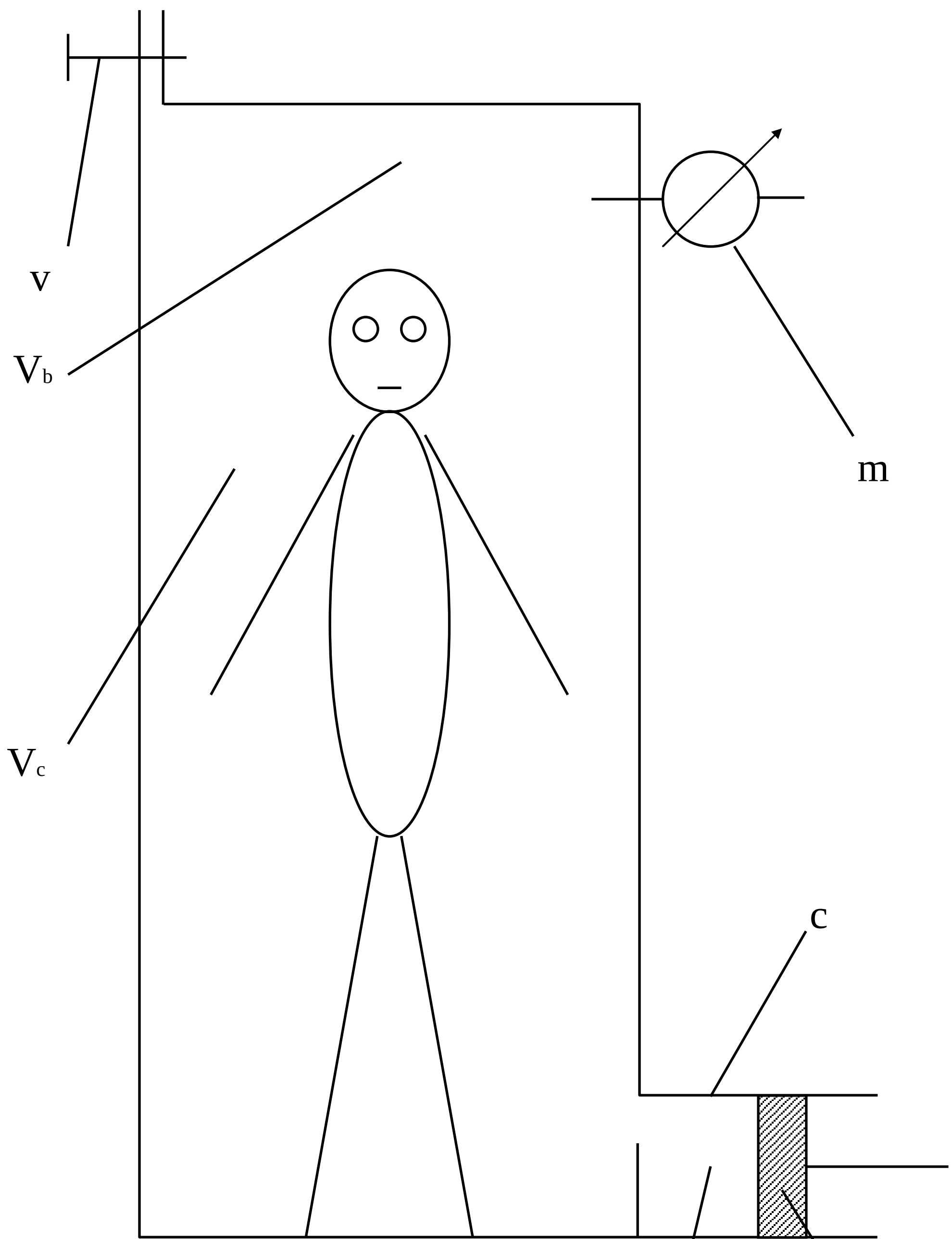
$(M_t - M_t')$ and $(V_t - V_t')$ are known from the measurements taken before and after the regime, then $(V_f - V_f')$ and $(V_w - V_w')$, therefore, the mass differential of fat and water can be calculated from (1) and (2) above.

CONCLUSION, RAMIFICATIONS, AND SCOPE OF THE INVENTION

Thus, we have presented the advantage of a method and device for determining the absolute amount along with variations of fat and water in the human body. Said advantage can be construed as the result of:

(a) Providing a simple, inexpensive and accurate device for determining fat and water absolute amounts and variations that could very easily be mass-produced,
(b) Providing a safe and rapid method of determining fat and water amounts and variations in the human body for institutional as well as domestic use.

While our foregoing description refers to a preferred embodiment, there are other possibilities and ramifications that extent the scope of the invention such as providing devices for determining the absolute amount and variations of fat and/or water adapted to any other living organisms.



v
Vb
Vc
m
c

FIG. 1