THE PUBLISHING HOUSE
OF THE ROMANIAN ACADEMY

MEDICINE
Research article

A NEW METHOD FOR ASSESING DISTRIBUTION OF THE ADIPOSE TISSUE USING 3D BODY SCANNING TECHNOLOGY

SIMONA CARNICIU[1], ROXANA STOICA[1], SIMONA STEFAN[1], DANIEL PETCU[2], CLAUDIA NICULESCU[2] and ADRIAN SALISTEAN[2]

[1] National Institute of Diabetes, Nutrition and Metabolic Diseases "N.C. Paulescu", Bucharest, Romania
[2] National Research and Development Institute for Textiles and Leather, Bucharest, Romania
Corresponding author: Simona Carniciu, E-mail: cassimona@yahoo.com

Accepted June 10, 2014

In the actual context of unstoppable increasing prevalence of obesity and metabolic syndrome, the adipose tissue became the main target tissue for research, as its inflammatory reaction on different tissues, in different degrees, are considered to be the substrate of decrease in insulin sensitivity, explaining the cardiovascular complications. Regarding the well-known relationship between obesity and type 2 diabetes, lately, the interests rose about the adipose tissue distribution and different methods to measure and determine it. A fast and informative new method is the noninvasive 3D scan with anthropometric cabin, used initially in apparel industry due its precise and complete 3D model of the human body. Later on, this method finds its way into clinical research. The purpose of our study was to identify the metabolic risk, the particularities of obesity in type 2 diabetic patients and so the cardiovascular risk in the general population. *Devices and method*: We used for the study the anthropometric cabin, 3D ANTHROSCAN (Human Solutions). This is an efficient system for serial measurements, made from hardware (body scan, VITUS Smart XXL) and software. Scanning of a subject last about 12 seconds and the automatic scan measures and calculates 150 dimensions in 60 seconds. Rules for positioning of the subject must be followed. We randomly selected 419 cases from a database, 245 females and 174 males, normal weight and various degrees of overweight subjects. Our results confirm that these 3 parameters used currently in practice (waist circumference, hip circumference and body mass index) are really the main indicators of overweight/obesity. The only additional method found in this study to be associated with the degree of obesity is neck-at-base circumference. *Conclusions*: The anthropometric cabin offers a large number of parameters regarding the distribution of adipose tissue that are not available by other common measurements. This study confirms that the waist circumference it's the main indicator of the degree of obesity. Approximately similar information could be obtained by the measurement of neck-at-base circumference. Although, the limitations of this measurement method are that does not provide data about the percentage of lean and fat mass.

Key words: obesity, diabetes, anthropometry, 3D body scanning.

INTRODUCTION AND OBJECTIVES

Obesity has become to be one of the most important issues in modern medicine, due to its unstoppable increasing prevalence, despite of the repeatedly warnings released by all international health organizations[1,2]. It is defined as the ponder excess with somatic, physiologic and social consequences that affects one's quality of life[3,4].

The interest for obesity was triggered by the discovery of the first two molecules indicating the secretory function of the adipocyte. The first was TNFα, discovered by Hotasmiligil in 1993[5] and the next year the discovery of leptin by Zhang *et al.*, that became the first hormone produced by adipocytes[6]. Later, the number of chemokine, cytokines or hormonal products has increased gradually approaching the number 100[3].

After the development of the metabolic syndrome concept, the adipose tissue became the main target tissue, able to explain the inflammatory reaction induced progressively by the "restless" adipocytes (that in contrast with normal, "quiet" adipocytes) has an increased amount of triglycerides and consecutively of their diameter/volume, ending in "aggressive" adipocytes which spills over a ray of adipocytokines with deleterious effects in various tissues: endothelial cells, skeletal muscle, liver. Collectively, these were considered to be the substrate of decrease in insulin sensitivity, explaining the cardiovascular complications[8,9].

Latest studies reveals that not so much the amount of adipose tissue, but its distribution contributes to the onset of metabolic disturbance in the human body[10,11] and so to the cardiovascular disease[12]. The relationship between obesity and diabetes is an "old couple"[13], but the mechanism of diabetogenic effect of obesity was clarified only in the last years[14-17]. Adipose tissue is an insulin dependent tissue and the increase in number of adipocytes will need a supplementary insulin secretion[18]. In people with a genetic predisposition on both obesity and type 2 diabetes it has been found that the main diabetogenic adipose tissue compartment was the intraabdominal one[19-23].

This rose the interest for a more objectively determination of the adipose tissue depots, apart the bioimpedance method. One, fast and objective (metric method), is the noninvasive 3D scan with anthropometric cabin. This method is usually used in clothing technology, due to its precise and complete 3D model of the human body. Beyond its application in textile industry, this 3D model scanning was adapted in the medical field, in clinical research, in order to determine the tendency of the dimensions and areas of the human body[24-28].

The last purpose of this study is to identify the metabolic risk, the particularities of obesity in type 2 diabetic patients and so the cardiovascular risk in the general population. In order to make such analysis, in this paper we randomly collected 419 cases from a larger database (about 2000 subjects) including 245 females and 174 males, normal weight and with various degree of overweight subjects. Data was processed in order to assess the relationship between various measured parameters selected from all 150 parameters, automatically scanned by the device Anhtroscan.

DEVICES AND METHOD

The continuous changing of the body dimensions due to increased prevalence of obesity, has affected also the apparel industry, therefore the need to reassess the sizes in order to conform the new trend. The National Research and Development Institute for Textiles and Leather started since 2009 a survey to evaluate different types of population in Romania. The study group is described below.

Technical description of the device and method

For a better understanding of the method, it requires a short description of the scanning technique of the anthropometric cabin, 3D ANTHROSCAN (Human Solutions). This is an efficient system for serial measurements, made from hardware (body scan, VITUS Smart XXL) and software.

Hardware consists from four laser sensors, eye-safe lasers and eight high-speed digital cameras (CCD = charge-coupled device cameras), a scale and two PCs[16].

Software is formed by a family of software like: (a) *ScanWorX Software* for the 3D Scanner for automatic measurements, visualize, processing and data evaluation; (b) *AnthroScan Software* for semiautomatic scans of the body. It can be set by its utilizer for large complex applications, in which several body positions are edited during measurement and then the results are combined in one measurement list. It combines the automatic efficacy and flexibility of the measure with the possibility of the utilizer to define his own individual rules of measurements according to his needs. This is based on the latest laser optic triangulation technology, according to EN ISO 20685.

Data collection: scanning of a subject last about 12 seconds and the automatic scan measures and calculates 150 dimensions in 60 seconds.

Rules for the positioning of the subject for scanning

In order to have a good scan, there is a protocol with instructions to the subject. He must be with as few clothes is possible and tight to the body, with no objects like watches, bracelets or chains, hair tied, without colors undetected by camera, like green, blue or black. There are two scanning positions: relaxed and standard (Figure 2). Positions of the limbs must be apart from any part of the body, so there will be no contact between them.

The subject enters the anthropometric room and stands still on a marked position while the quick scan starts during a full exhalation.

Study group

Subjects were randomly selected from patients presented for check-up at Diabetes Centre "Ion Pavel" from National Institute of Diabetes, Nutrition and Metabolic Diseases "N.C. Paulescu", Bucharest, Romania.

We analyzed 419 patients, 245 females and 174 males. Data taken into consideration were: age, sex, diabetic or nondiabetic. Selected measurements are given in Figure 3.

Statistical analysis

Data collected by the two PCs of the Anthroscan, were analyzed using specific features in Microsoft Excel 2010 program.

Analysis of variance is a collection of statistical models used in order to analyze the differences between group means and their associated procedures (such as "variation" among and between groups). It provides a statistical test of whether or not the means of several groups are equal, and therefore generalizes the *t*-test to more than two groups[29].

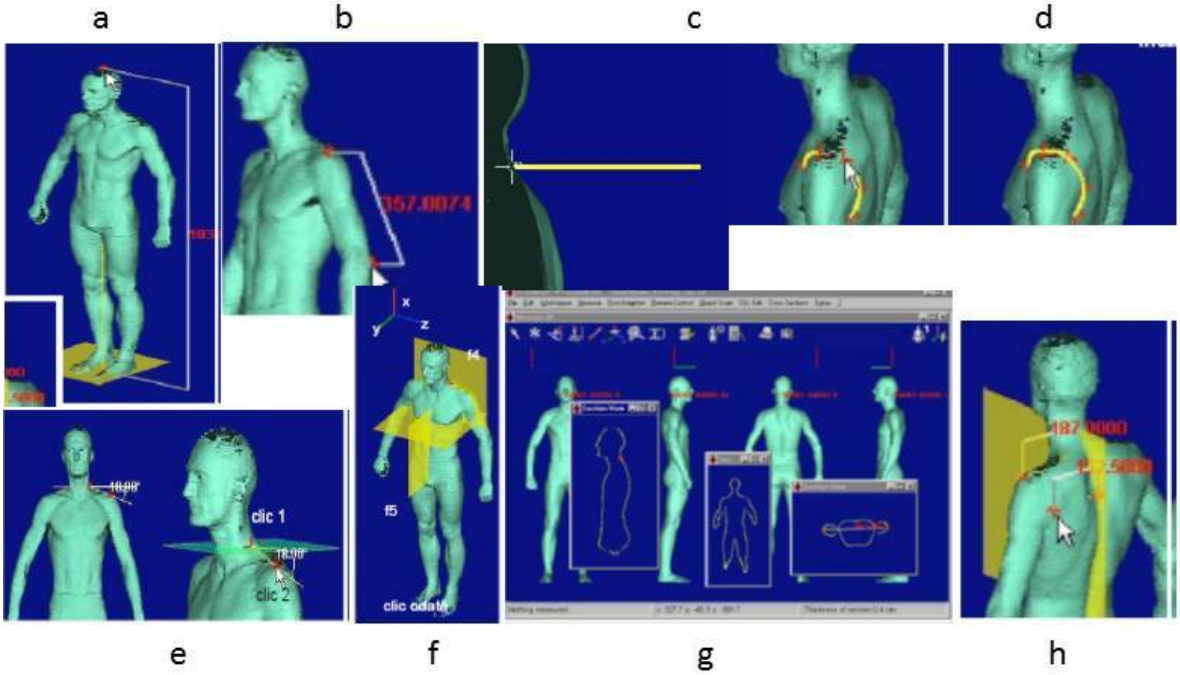

Figure 1. Automatic measurements of dimensions and circumferences by the anthropometric cabin.

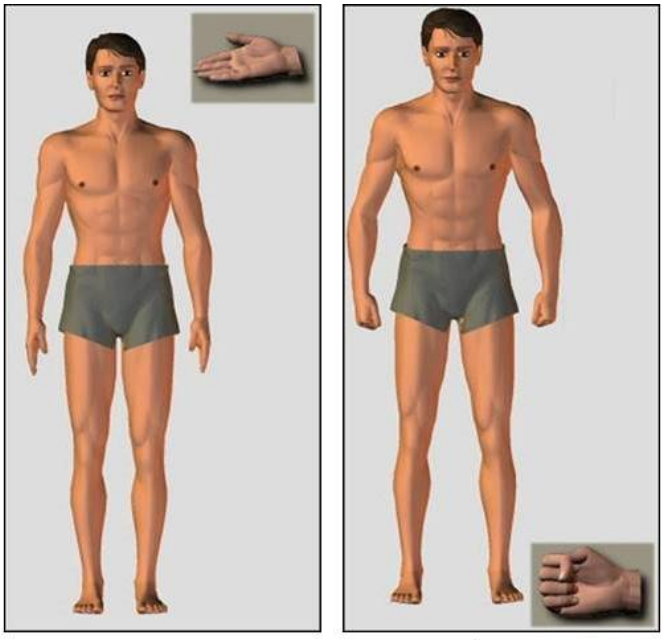

Figure 2. Scanning positions: (a) relaxed and (b) standard.

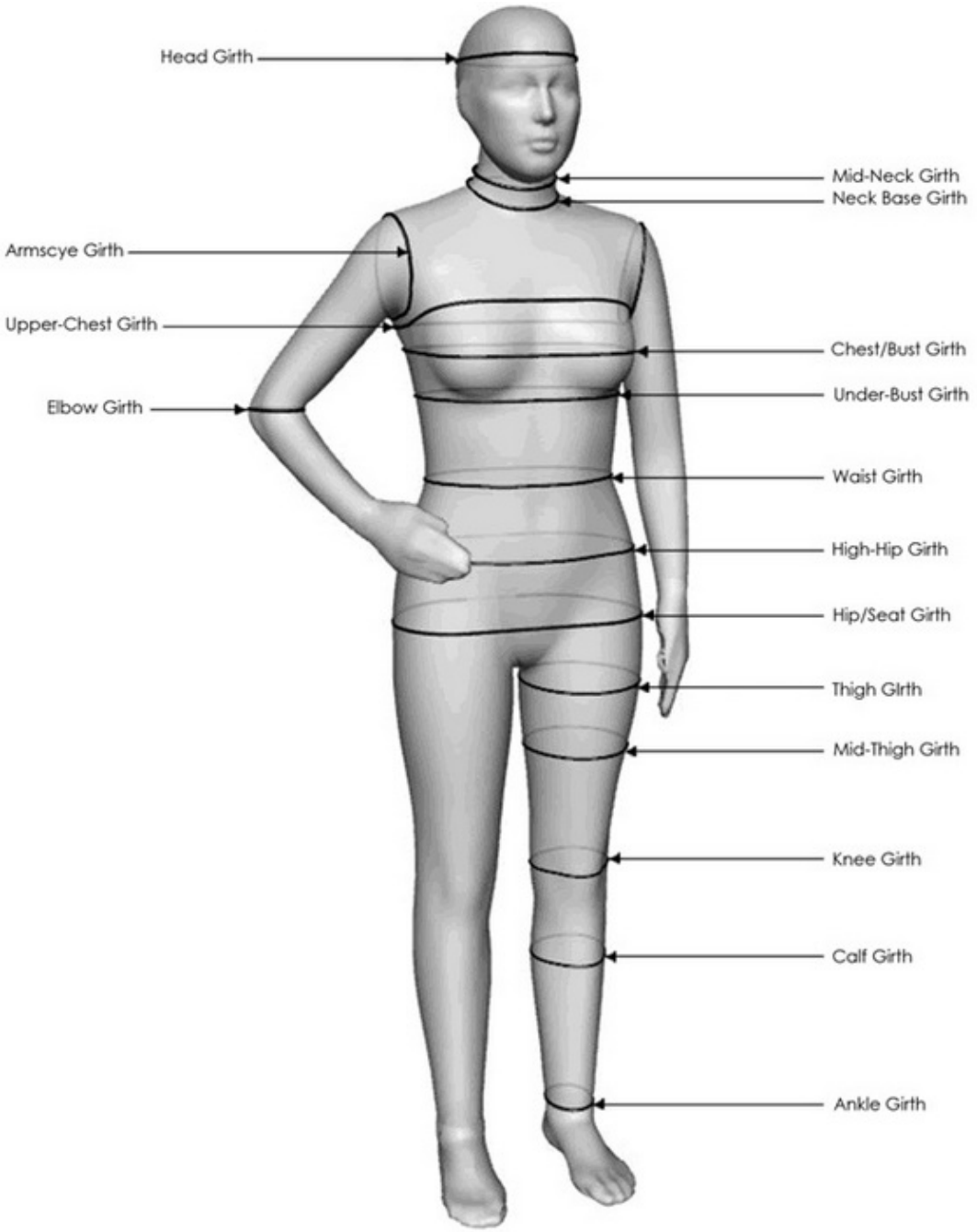

Figure 3. A schematic representation of the measurements analyzed in this study.

RESULTS AND DISCUSSIONS

Analysis of various parameters determined in our study group, is given in Table 1 (for females) and in Table 2 (for males).

In the Figure 4 is given a typical model of abdominal (android) morbid obesity in a female.

We give in the Figure 5 the ratio between waist girth and neck-at-base girth in women (a) and males (b).

Table 1

Analysed parameters in women

Females

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Shoulder angle left	245	5804.1	23.6902	27.78318		
Shoulder angle right	245	5991.3	24.45429	17.64421		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	71.51804	1	71.51804	3.148674	**0.076612**	3.860584
Within Groups	11084.28	488	22.7137			
Total	11155.8	489				
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Shoulder width left	245	3829.2	15.62939	15.81151		
Shoulder width right	245	3641	14.86122	5.173613		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	72.28416	1	72.28416	6.889086	**0.008944**	3.860584
Within Groups	5120.37	488	10.49256			
Total	5192.654	489				

Table 2

Analyzed parameters in men

Males

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Shoulder angle left	174	3962.6	22.77356	36.10889		
Shoulder angle right	174	4156.7	23.88908	32.81682		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	108.2609	1	108.2609	3.141381	0.077209	3.868475

Table 2 (continued)

Within Groups	11924.15	346	34.46285			
Total	12032.41	347				
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Shoulder width left	174	2788.6	16.02644	25.70334		
Shoulder width right	174	2691.7	15.46954	29.95774		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	26.98164	1	26.98164	0.969497	0.325494	3.868475
Within Groups	9629.367	346	27.83054			
Total	9656.349	347				

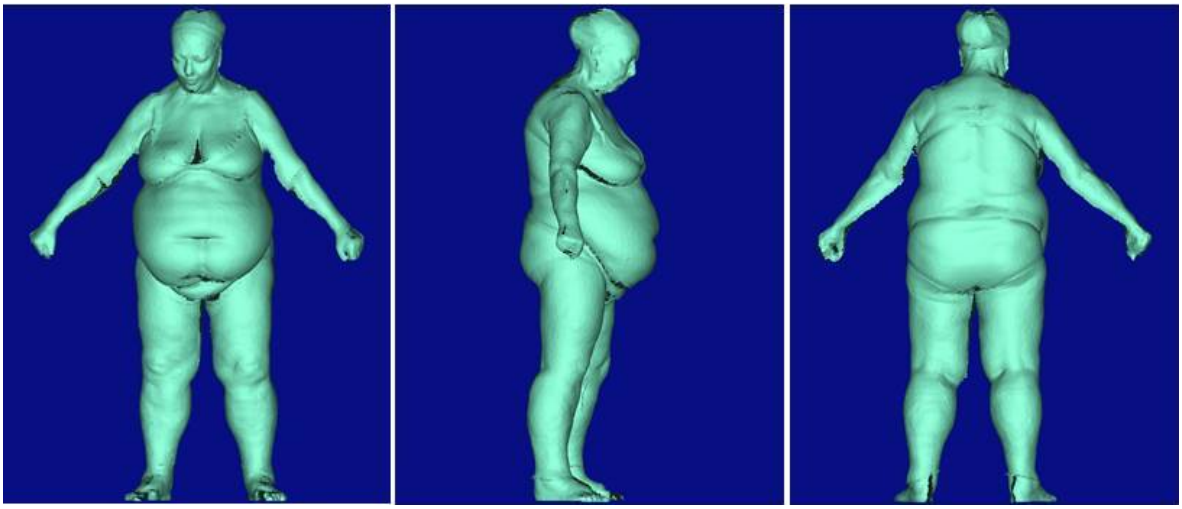

Figure 4. Typical abdominal obesity. 3D images of a random female subject, obtained from data analysis of the anthropometric cabin.

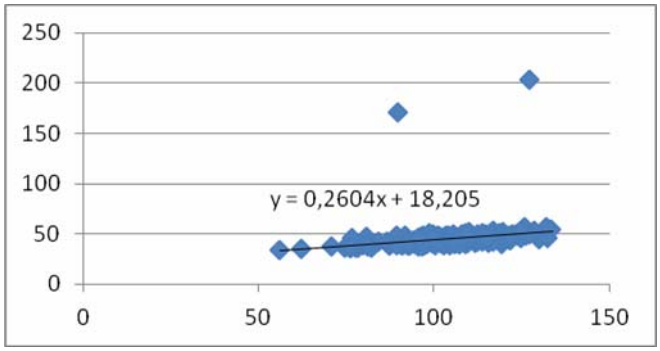

Figure 5a. Waist girth and neck at base girth in women

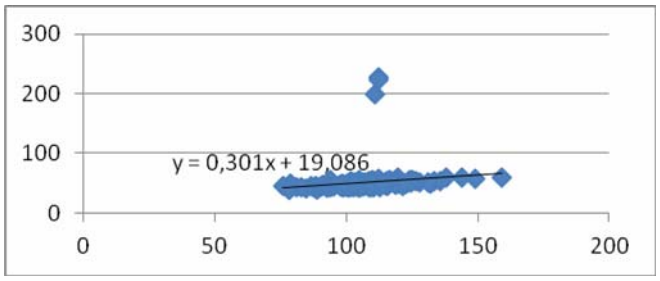

Figure 5b. Waist girth and neck at base girth in men.

As can be seen there is a very good correlation between these two parameters, suggesting that the neck at base girth is a useful and simple additional method to determine the degree of obesity.

Our data shows that apart the BMI, which is the main clinical parameter used in current medical practice, using anthropometric cabin we found several other indicators of degree of obesity. Will be of great interest if using these new parameters (such as neck at base circumference) correlates also with pathogenicity of excess adipose tissue.

It is worthy of note that in the last time, has been introduced in the study of obesity new terms like "healthy metabolic obesity" and "non-healthy metabolic obesity"[30], according with the lipid profile of various patients as well as the presence or not of the cardiovascular complications.

Finally, in future will be necessary to select from the various anthropometric, metabolic and hormonal parameters, those indicating with a strong probability, the evolution to type 2 diabetes.

CONCLUSIONS

1. Data analyzed with the anthropometric cabin offers a large number of parameters regarding the distribution of adipose tissue that are not available by other common measurements.

2. These data confirms that the most simple indicators used in clinical practice, like body mass index or abdominal circumference, are strongly correlated with several indicators obtained from segmental analysis (neck, upper arms and head circumference) in anthropometric cabin.

3. This study confirms that the waist circumference it's the main indicator of the degree of obesity. Approximately similar information could be obtained by the measurement of neck-at-base circumference.

4. The limitations of this measurement method are that does not provide data about the percentage of lean and fat mass, two important parameters that are necessary for understanding the pathogenicity of obesity.

5. Our future objectives are to expand this study with a parallel determination of lean and fat mass in subjects in their clinical context.

6. Another step will be the careful analysis of the both methods (anthropometric cabin and bioimpedance one) in diabetic versus non-diabetic patients.

REFERENCES

1. WHO. Obesity: preventing and managing the global epidemics. Report. WHO, Tech Rep Ser 894:1-253, 2000.
2. Birmingham CL, Muller JL *et al.* The cost of obesity in Canada. CMAJ 1999; 160(4):483-488.
3. Basdevant A, Guy-Grand B. Medicine de l'obesite. Editions Flammarion, Paris, 2004.
4. Alberti KG, Zimmet PZ Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med 1998; 15:539-553.
5. Hotamisligil GS, Shargill NS, Spiegelman BM. Adipose expression of tumor necrosis factor-alpha: direct role in obesity-linked insulin resistance. Science 1993; 259:87-91.
6. Zhang Y, Proenca R, Maffei M *et al.* Positional cloning of the mouse obese gene and its human homologue. Nature 1994; 372:425-432.
7. Chaldakov GN, Fiore M, Ghenev PI, Stankulov IS, Aloe L. Atherosclerotic lesions: possible interactive involvement of intima, adventitia and associated adipose tissue. Int Med J 2000; 7:43-49.
8. Ionescu-Tîrgovişte C. Insulin Resistance - What is myth and what is reality? Acta Endocrinologica (Buc) 2011; 7(1):123-146.
9. Ionescu-Tirgoviste C, Vasilescu R, Timar R, Guja C, Gagniuc P, Bacanu E, Gligor R, Carniciu S. The proinsulin-to-adiponectin ration could be the best practical indicator for the early (prehyperglycaemic) phase of type 2 diabetes. Adipobiology 2012; 4:41-50.
10. Kissebah AH, Krakower GR. Regional adiposity and morbidity. Physiol Rev 1994; 74:761–811.

11. Wajchenberg BL. Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. Endocr Rev 2000; 21(6):697-738.
12. Vega GL. Obesity, the metabolic syndrome and the CV disease. Am Heart Disease 2001; 142:1108-1116.
13. Bierman EL, Bagdage JD, Porte D Jr. Obesity and diabetes: the old couple. Am J Clin Nutr 1968; 21:1434.
14. Nedergaard J, Cannon B. The changed metabolic world with human brown adipose tissue: therapeutic visions. Cell Metab 2010; 11: 268–272.
15. Ionescu-Tirgoviste C, Vasilescu R, Timar R, Guja C, Gagniuc P, Bacanu E, Gligor R, Carniciu S. The proinsulin-to-adiponectin ration could be the best practical indicator for the early (prehyperglycaemic) phase of type 2 diabetes. Adipobiology 2012; 4:41-50.
16. Ionescu-Tîrgovişte C. Insulin, the molecule of the century. Arch Physiol Biochem1996; 104: 1-7.
17. Dullo A.G.: Adipose tissue plasticity in catch-up-growth trajectories to metabolic syndrome. Diabetes 2009; 51: 1037-1039.
18. Ionescu-Tirgoviste C., "Prolegomenon to the European Constitution Book of diabetes mellitus". Proc. Rom. Acad., Series B 2008; 3:179–213.
19. Wajchenberg BL. Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. Endocr Rev 2000; 21(6):697-738.
20. Angel A., Hollenberg C.H.,Roncari DAK.: The Adipocyte and Obesity: Cellular and Molecular Mechanisms. Raven Pres 1983.
21. Avram AS, Avram MM, James WD. Subcutaneous fat in normal and diseased state. J Am Acad Dermatol 2005; 53:671-683.
22. Sironi AM, Petz R, De Marchi D, Buzzigoli E, Ciociaro D, Positano V *et al.*, Impact of increased visceral and cardiac fat on cardiometabolic risk and disease. Diabet Med 2012; 29: 622–627.
23. Weiss R. Fat distribution and storage: how much, where, and how? European Journal of Endocrinology 2007; 157 S39–S45.
24. Daniell, N., T. Olds, and G. Tomkinson, Technical note: Criterion validity of whole body surface area equations: A comparison using 3D laser scanning. Am J Phys Anthropol 2012; 148(1):148-155.
25. Yu, C.Y., Y.H. Lo, and W.K. Chiou, The 3D scanner for measuring body surface area: a simplified calculation in the Chinese adult. Appl Ergon 2003; 34(3):273-278.
26. Petrescu L., Strungaru C.A., Mihailescu D.F., Salistean A., Niculescu C., Ionescu-Tirgoviste C. 3D body scanning technology, a method for assessing early risk of diabetes. Proc Rom Acad, Series B 2012; 1:3-8.
27. Lin, J.D., *et al.*, Application of three-dimensional body scanner: observation of prevalence of metabolic syndrome. Clin Nutr, 2004; 23(6):1313-1323.
28. Chiou, W.K., *et al.*, Correlation of the dysmetabolic risk factors with different anthropometric measurements. Endocr J, 2005; 52(1):139-148.
29. http://en.wikipedia.org/wiki/Analysis_of_variance. Accessed online on 9 June, 2014.
30 Karelis A.D., St-Pierre D.H., Conus F., Rabasa-Lhoret R., Poehlman E.T.: Metabolic and body composition factors in subgroup of obesity: what do we know? J Clin Endocrinol Metab 2004; 89:2569-2575.