

Original article

Prevalence of metabolic syndrome parameters in a Romanian population of young adults

Parametrii sindromului metabolic la o populație de tineri adulți din România

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Abstract

Objectives: To investigate the prevalence of the metabolic syndrome and its components among a Romanian population of young adults. *Methods:* During 2010-2011, 235 medical students were enrolled in this cross sectional study to investigate the metabolic syndrome prevalence. The metabolic syndrome was defined based on the International Diabetes Federation criteria. Data were processed using SPSS version 17. T-student test, Chi square test and Pearson coefficient were used for statistical analysis. *Results:* The metabolic syndrome prevalence recorded on the entire group was 1.28%. The highest prevalence for a metabolic syndrome component was abnormal waist circumference (49.4%), followed by low levels of high density lipoprotein cholesterol (HDLc) (13.58%); the prevalence of hypertriglyceridemia was 3.08%. The average value of HDLc was significantly lower in the subgroup with abnormal waist circumference compared to the subgroup with a normal one both in women and in men. In women, the average BMI was also significantly higher in the subgroup with waist circumference above the threshold limit. In terms of gender analysis, women presented a significantly higher prevalence of abnormal waist abdominal circumference. (63.6% versus 15.7%). *Conclusions:* Although the prevalence of metabolic syndrome was not high (1.28%), the high prevalence (49.4%) of the mandatory diagnosis criteria (WC over a threshold value) allowed us to conclude that primary prevention interventions for metabolic syndrome are needed within the population group represented by young adults.

Keywords: metabolic syndrome, waist circumference, high density lipoprotein cholesterol

Rezumat

Obiective: Investigarea prevalenței sindromului metabolic și a componentelor sale într-o populație de adulți tineri din România. *Metode:* În perioada 2010-2011, 235 studenți la medicina au fost înrolați într-un studiu transversal destinat investigării prevalenței sindromului metabolic, definit pe baza criteriilor International Diabetes Federation. Datele obținute au fost prelucrate folosind programul SPSS versiunea 17. Pentru analiza

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statistica s-au folosit testul T-student, testul Chi pătrat și coeficientul Pearson. Rezultate: În întregul grup s-a înregistrat o prevalență a sindromului metabolic de 1.28%. Cea mai ridicată prevalență a unui component al sindromului metabolic a fost circumferința abdominală (CA) anormală (49.4%), urmată de nivelul scăzut al colesterolului din lipoproteinele cu densitate mare (HDLc) (13.58%); prevalența hipertrigliceridemiei a fost de 3.08%. Valoarea medie a HDLc a fost semnificativ mai mică în subgrupul cu CA peste valoarea normală, comparativ cu grupul cu CA normală, atât pentru femei cât și pentru bărbați. La femei, media indicelui de masă corporală (IMC) a fost semnificativ mai mare în subgrupul cu CA peste limita normală. În ceea ce privește analiza pe genuri, femeile au prezentat o CA anormală cu o prevalență semnificativ mai mare decât bărbații (63.6% versus 15.7%). Concluzii: Deși prevalența sindromului metabolic a fost redusă (1.28%), prevalența ridicată (49.4%) a criteriului obligatoriu de diagnostic al acestuia (CA peste valoare prag) ne-a permis să concluzionăm că sunt necesare intervenții de preventie primară a factorilor de risc ai sindromului metabolic în grupul populațional reprezentat de adulții tineri.

Cuvinte cheie: sindrom metabolic, circumferința abdominală, high density lipoprotein cholesterol

Introduction

Diagnosis of metabolic syndrome involves an association between central obesity and at least 2 of the following criteria: systolic blood pressure (SBP) > 130 mmHg and/or diastolic blood pressure (DBP) > 85 mmHg, increased fasting glucose, low high density lipoprotein cholesterol (HDLc), and high value of triglycerides. In the context of the metabolic syndrome diagnosis a relationship of synonymy is accepted between central obesity and exceeding the threshold value of waist circumference (WC). Although the actual criteria are the same, National Cholesterol Education Program (NCEP) in the United States differs from the recommendations of the International Diabetes Federation (IDF), usually applied in European countries in terms of both limits considered normal waist circumference and for the threshold of glucose (1, 2).

Obesity is the most important risk factor for metabolic syndrome. From data recorded and reported to the Ministry of Health (Romania) and to the World Health Organization (3), we know that there is a national overweight prevalence of 33.1% and the obesity prevalence is 8.6%. The male / female ratio is in favor of the first for overweight (prevalence of 38.1% in men and 28.6% in women), but in favor to females for obesity (prevalence of 7.7% in males and 9.5% in females). Obesity is the consequence of inadequate diet intake-energy consumption, according to the type and frequency of physical activi-

ty. Both type and amount of the food intake are important to assess. The so called "unhealthy" food or "urbanized" eating or simply low quality food (*Junk food*) (4-7) is the term used to describe foods with low nutritional value, with rich content of saturated fats and sugar, hyper calories, low in vitamins and minerals or high quality protein, whose consumption increases the risk of obesity. All population studies in the last decades have shown that metabolic syndrome occurs at younger ages; the reasons most frequently given are "*junk food*" and physical inactivity that increasingly characterizes more children and adolescents' lifestyle. The incidence of overweight between the ages of 7 and 11 years is reported in most European countries, reaching high levels, over 15% (3). So far, there were no research results published in Romania on the prevalence of metabolic syndrome - or its components – in the young population. In this context, we initiated a prospective study to evaluate the metabolic syndrome parameters (abdominal circumference, fasting glucose, triglyceride levels, HDLc level, blood pressure value), feeding behaviour (8,9) and physical activity level in a population of 235 medical students; this group will be re-evaluated after 1 year for all study parameters, to refer to any behavioural changes, anthropometric and biological measurements. In this article we present baseline findings regarding the prevalence of metabolic syndrome main parameters recorded.

Methods

The first stage of the study was conducted in 2010-2011 on a sample of 235 students of the Faculty of Medicine. Students in the first five years of study were invited to participate in the study. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Ethics committee of the National Institute of Infectious Diseases "Prof. Dr. Matei Balș". All participants signed an informed consent document regarding the conduct of the study.

None of the subjects has been previously diagnosed with diabetes and was never treated with antihypertensive medication. Age of students ranged from 19-30 years with an average of 21.82 years (standard deviation = 2.32, coefficient of variation 10.6%). There were 165 women and 70 men. Female preponderance reflects the medical students' population structure. As definition criteria of the metabolic syndrome are different in men versus women, data analysis was done by gender. Where considered relevant, we presented the overall results.

All subjects were measured for the following anthropometric parameters: height, weight, waist circumference. Height was measured using the height meter and weight with the scale. Waist circumference was measured using the height meter for waist circumference midway between the superior iliac crest and rib cage, on umbilical level and hip circumference was measured at the trochanteric level. Means and variances calculated for anthropometric parameters are presented in *Table 1*. Blood pressure was measured using the following protocol: first measurement was made after at least 5 minutes of rest and was repeated 3 times, keeping 1 minute of interval between each measurement. Final data is the average of 3 measurements.

Blood samples were collected from the antecubital vein, in the early morning, after a minimum of 12 hours of fasting period, in a supine position. Biochemical determinations were made in the National Institute of Infectious Dis-

eases "Prof.Dr.Matei Balș" laboratory by standard biochemical methods.

In processing and data analysis threshold values of the metabolic syndrome components of the International Diabetes Federation were used. Statistical analysis: The quantitative variables were discussed as mean, SD and the t-student test was used for comparison. A p-value <0.05 was considered for statistical significance (two tailed test). Categorical data were presented as proportions and compared by using the Chi square test ($p<0.05$). Microsoft Office Excel 2007 for Windows was used for the entry of data and for creating the charts. Statistical analyses were performed with the SPSS version 17.0.

Results

The investigated subjects showed the anthropometric characteristics summarized in *Table 1*. Average values are included in the normal value range for all measured parameters. In women there was a strong positive correlation between BMI and abdominal circumference (Pearson $r = 0.765$, $p = 0.001$), while in men this correlation was very weak and statistically insignificant (Pearson $r = 0.06$, $p = 0.62$).

As waist circumference is a mandatory diagnostic element of the metabolic syndrome, we initially analyzed the distribution of this feature in the population of women and men (*Figure 1*).

Results found for the group of women

Using a threshold of 80 cm for the WC, we divided the female population into 2 groups: women with WC over 80 cm and women with WC below this threshold. Analyzing the average parameters of metabolic syndrome in both groups, we found a statistically significant difference in body mass index value (BMI) and HDLc (*Table 2*).

There were 105 (63.6%) women with $WC > 80$ cm. Of these, only two women (with $WC = 86$ and 112 cm respectively) have met 3 criteria and, consequently, diagnosed with metabolic syndrome. The first case associated a BP of $120/90$ mmHg and glucose of 104 mg/dl,

Table 1. The main anthropometric characteristics of the students' population

	Weight (kg)		Height (cm)		BMI (kg/m ²)		Waist circumference (cm)		Hip circumference (cm)		Ration Abdominal circumference / Hip circumference	
	W	M	W	M	W	M	W	M	W	M	W	M
average	57.61	72.46	165.44	179.51	21.04	22.46	83.58	86.30	98.47	99.89	.8486	.8634
standard deviation	9.24	11.07	5.708	7.287	3.179	3.085	8.611	8.713	8.194	8.095	.04906	.03686
maximum	98	120	183	197	37	38	117	130	130	144	.96	.95
minimum	40	53	152	164	15	17	65	73	84	85	.70	.77

BMI = body mass index

Table 2. Average and standard deviation values of the metabolic syndrome parameters in women, depending on the value of waist circumference

Measured parameter	WC< 80 cm		WC>80 cm	
	average	standard deviation	average	standard deviation
BMI* (kg/m ²)	19.12	1.94	22.12	3.24
Systolic blood pressure (mmHg)	108.88	10.64	108.35	9.03
Diastolic blood pressure (mmHg)	67.24	9.96	66.96	7.81
Fasting plasma glucose (mg/dl)	79.67	8.88	81.31	9.00
Triglycerides (mg/dl)	71.66	29.77	77.25	40.28
HDLC* (mg/dl)	71.16	11.79	63.40	14.87

WC= waist circumference; BMI= body mass index; HDLC = high density lipoprotein cholesterol

*statistically significant differences, Student's t, p <0.05

and the second a value of triglycerides of 185 mg/dl and a HDLC value of 31 mg/dl. We recorded in women with WC> 80 cm the following changes in the parameters of metabolic syndrome: 16 abnormal values of HDLC, 2 elevated blood glucose values, 2 elevated triglycerides values, 1 person with SBP and another one with DBP over limits. In total, there were 21 women with WC> 80 cm having 2 metabolic syndrome criteria present. In the group of women with WC<80 cm we found that, in total, 15 women had values considered as abnormal by IDF, as follows: 4 persons had SBP> 130 mmHg, 4 persons DBP> 85 mmHg, 4 persons HDLC<50 mg/dl, 2 persons TGL> 150 mg/dl and 1 person had fasting glucose > 100 mg/dl.

In conclusion: there were 82 women (63.6%) with 1 element of metabolic syndrome present (WC), 21 women (12.7%) with 2 ele-

ments present and 2 (1.2%) with a complete metabolic syndrome.

Results found for the group of men

In this group there were 11 of 70 men (15.7%) with WC> 94 cm. Of these only one presented 3 criteria for metabolic syndrome (WC = 96 cm, a HDLC= 35 mg/dl and DBP = 90mmHg). Comparison of this group's average with that of men with WC <94 cm is presented in Table 3. In the group with WC> 94 cm, 7 subjects had abnormal values according to IDF: 3 had increases in SBP and 4 had HDLC changes to the threshold. They are the group of 7 persons with 2 criteria of the metabolic syndrome present. In the group of men with WC <94 cm, there were 1 with 2 criteria (high SBP and high TG), 8 with high SBP, 1 with high TGL, 4 with abnormal HDLC values and 1 with high fasting blood sugar level.

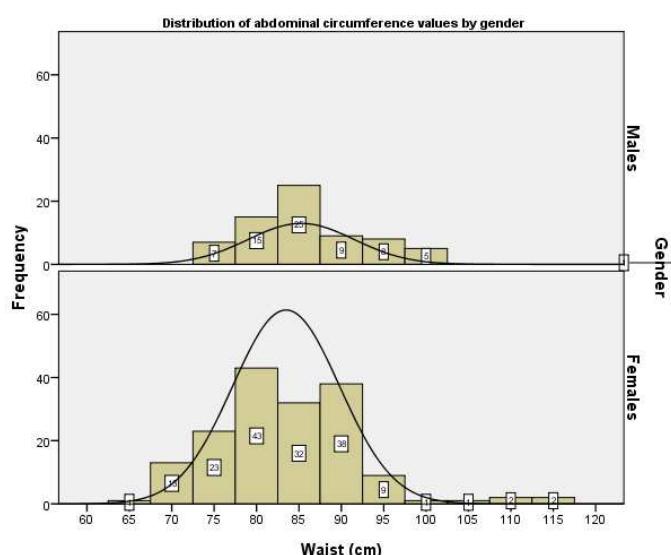


Figure 1. Distribution of waist circumference by gender

In conclusion, in the whole men group, there were 25 men (35.7%) who had 1 element of metabolic syndrome, 8 (11.4%) who had 2 elements and 1 (1.4%) with 3 diagnostic criteria present.

In the entire group of 235 people, the most common change was the WC: 49.4%, mainly due to high prevalence of this change in women (63.6% versus 15.7% for men). Another highly modified parameter is HDLc (13.58%); this change is more common in women than in men (14.5% vs. 10.14%). Elevated values using the criteria for metabolic syndrome were found for SBP in 2.6% and for DBP in 3.4% of the investigated subjects. Blood glucose levels above the threshold were present in 2.6% of cases and hypertriglyceridemia in 3.08% of cases. We found significant differences in the prevalence of risk factors by gender only for abnormal waist circumference (*Table 4*), in contrast with other studies, showing much lower differences (10). High WC is an estimate of the visceral fat, expected to be 10-20% of total fat in men and 5-8% in women (11); these physiologic differences explain the different threshold gender related for WC.

The prevalence of the metabolic syndrome in our group was 1.28%. By using NCEP criteria in

our group, the prevalence of metabolic syndrome in women was only 0.6%; none of the men investigated met 3 criteria covered by the NCEP definition of metabolic syndrome.

Discussions

Studies published so far on the Romanian population made little reference to this age group; most included the entire population or strictly analyzed the school population. For example, a study performed on the Timis county general population showed a prevalence of adult metabolic syndrome of 36.67%, a figure that positions us above the European average, but unlike our study, this study was conducted on a population aged

between 18-79 years (12). As metabolic syndrome prevalence varies with age (13, 14), it is interesting to choose the group which ended the growing period and thus has a required food intake mostly dependent on the total physical activity, and in which social behavior (including food habits) has evolved past the adolescence period and became more stable. Subjects chosen by us are part of a better informed social class than the average population regarding the risks of unhealthy dietary intake; this can be considered an important influence factor. However, high prevalence of central type obesity, estimated in terms of definition of metabolic syndrome, in almost half of respondents (49.4%) and especially in women, is an unexpected element observed. We do not have a full explanation for this unexpected result, but most probably it is related to differences in physical activity evaluated by the level of recreational activity in kcal ($p<0.001$, data not published).

WC is used to assess obesity related health risks in public health and clinical setting (15), as it is the best clinical estimate of visceral obesity. Visceral obesity has an important role in increasing cardio-vascular and diabetes risk. Comparing to subcutaneous fat, the visceral one has more sensit-

Table 3. Average and standard deviation values of the metabolic syndrome parameters in men, according to the value of waist circumference

Measured parameter	WC< 94 cm		WC>94 cm	
	average	standard deviation	average	standard deviation
BMI* (kg/m ²)	21.7	2.248	26.37	4.075
Systolic blood pressure (mmHg)	117.24	10.686	119.55	10.113
Diastolic blood pressure (mmHg)	72.84	8.383	75.91	7.355
Fasting plasma glucose (mg/dl)	81.71	8.146	83.09	6.472
Triglycerides (mg/dl)	76.9	38.179	76.18	25.459
HDLC* (mg/dl)	54.81	11.166	48.36	11.526

WC= waist circumference; BMI= body mass index; HDLC = high density lipoprotein cholesterol

* statistically significant differences, Student's t, p <0.05

Table 4. Differences by gender in the prevalence of the metabolic syndrome diagnostic criteria

Metabolic syndrome parameter	OR	CI
Waist circumference*	0.1	0.05041, 0.2159
SBP	4.9	0.6838, 55.4
DBP	1.4	0.2161, 7.593
Glucose	0.465	0.009667, 4.267
Triglycerides	0.941	0.08762, 5.924
HDLC	0.6539	0.2258, 1.669

SBP= systolic blood pressure; DBP= diastolic blood pressure; HDLC = high density lipoprotein cholesterol

* statistically significant differences, Student's t, p <0.05

ive α -receptors, more glucocorticoid receptors, produces and more adipokines with inflammatory role such as tumor necrosis factor α and interleukin 6 (IL6) (16). The result of β -receptors' activation is lipolysis that generates free fatty acids (FFA) into the portal circulation. FFA impairs glucose utilization in several ways: inhibits carbohydrate oxidation, reduces glucose uptake in cells stimulated by insulin and diminishes glycogenogenesis (17). Through all these mechanisms, FFA significantly contribute to the development of insulin resistance.

Inflammation and oxidative stress generated by adipokines induce endothelial dysfunction and vascular hypertrophy, while IL-6 mediates the action of angiotensin II on vascular smooth muscle cells (18), creating conditions for the obesity related hypertension (19). For reasons described above, the high prevalence of abnormal WC recorded in this population has significant consequences for their health risks.

Framing our results in other studies, we found that the prevalence of metabolic syndrome in Europe for the entire adult population, according to IDF criteria, ranges from 27%-39% in men and 22-47% in women, depending on the country (13). As mentioned above, Romania is in the upper part of the prevalence range, with a value of 36.67%. Even if the prevalence reported in the United States appears to be smaller (34%) (10), because of choosing a higher threshold for WC, in reality – when identical threshold values are used - it becomes greater.

For a more relevant comparison we selected studies that focused on - or used as subgroup - young adults between 20-39 years; Ervin et al. finds a WC above normal values in 32% of the subjects (10), hypertriglyceridemia in 29.6%, HDLC decreased in 21.4%, BP values above the established limits in 24.1% and alteration of fasting glucose or diabetes in 28.8%. All these values recorded are above the number we have found; these

could be explained by the older age of the subjects enrolled in this study. As we narrow the age range more (20), prevalence becomes comparable: similar prevalence is found in an American group for low HDLc (13.58% in our study to 13.5% in the American one) and for hypertriglyceridemia (3.08% versus 2.5%), i.e. for variables whose threshold is similar in both surveys. In Finland (21), the prevalence of metabolic syndrome was, at the age of 24 years, of 4%, higher than that found by us (1.2%); the difference may appear in the greater number of cases analyzed in the Finnish study (21), the differences arising from social stratification, and the composition of different diets. Authors performing studies on different ages populations noted an increase of the prevalence of metabolic syndrome with increasing in age: Matesson et all (21) mentioned an increase in 15 years (from 24 to 39 years) from 4% to 25.9%, Ervin found that the chance of having metabolic syndrome, compared with that in the 20-39 years age range is 3 times higher in 40-59 years (both women and men), 4 times in men over 60 years and 6 times higher in women over 60 years (10). Based on these results, even if the incidence of metabolic syndrome found in this group is small, it does nothing to diminish the interest for prevention in this target group.

Most studies having as purpose the research of the prevalence of individual criteria for metabolic syndrome and the metabolic syndrome showed a significantly higher prevalence in men at ages under 30 years. Fereirra et al (22) communicates a prevalence of metabolic syndrome in the Netherlands of 18.3% in men vs. 3.2% in women, and Soysal et al (23) a prevalence of 11.8% in men and 6.2% in women ($p = 0.007$) in Turkey; in both studies NCEP criteria have been used. The Turkish population study concluded that the metabolic syndrome significantly increases in people with low levels of education. From this perspective, lower prevalence results obtained by us are consistent. We have found that women have more frequent changes of the metabolic syndrome criteria, with a statistically significant difference between prevalences. In the Finnish study (21) cited above, the au-

thors make similar observations with the ones we found: for the population of 24 years there is a higher prevalence of metabolic syndrome in women than in men, main gender differentiation is given by the criterion on abdominal obesity (15.7% in men versus 26.5% in women).

In the general population of young adults, risk factors for metabolic syndrome may be more frequent; compared to our group, the general population has less medical knowledge on nutritional facts and of the consequences of their diet.

Due to the number of participants, we cannot extrapolate our results to the whole Romanian young adult population. However, the accuracy of the methodology and the level of significance between the measured characteristics allow us to support our conclusions. In order to verify the prevalence found, a larger epidemiological study is needed.

Conclusions

In students with an average age of 22 years, we found a higher prevalence (49.4%) of WC compared to previously published studies on populations of similar age and similar prevalence of low levels of HDLc (13.58%) and hypertriglyceridemia (3.08%). Usually, abdominal fat increases with aging independent of the weight gain; from this perspective, the high prevalence of WC founded in these young adults has great significance.

Prevalence of metabolic syndrome as meeting of minimum 3 IDF criteria was relatively small (1.28%) and approximately equally distributed between sexes (1.2% in women versus 1.4% in men). A statistically significant difference between women and men was found only in terms of the modification of waist circumference, with a higher prevalence in women. Although the prevalence of metabolic syndrome was not very high, the high prevalence of the mandatory diagnosis criteria (WC over a threshold value), together with a tendency for increased prevalence by aging confirmed by other studies, allow us to conclude that primary prevention interventions of metabolic

syndrome are also needed within the population group represented by young adults.

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References

- National Institutes of Health, Heart, Lung, and Blood Institute - Third Report of the National Cholesterol Education Program (NCEP). Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation*. 2002; 106: 3143-421
- Alberti KG, Zimmet P, Shaw J. Metabolic syndrome-a new world-wide definition. A consensus statement from the International Diabetes Federation. *Diabet Med*.2006; 23(5):469-480
- WHO Global database - Data for saving life: NCD Indicators: <https://apps.who.int/infobase/Indicators.aspx>
- Popkin M., Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. *Int J Obes*. 2004; 28, S2-S9.
- Bayol S, Macharia R, Farrington S, Simbi B, Stickland N. (2009) Evidence that a maternal "junk food" diet during pregnancy and lactation can reduce muscle force in offspring, *Eur J Nutr*. 2009; 48:62-65
- Unger JB, Reynolds K, Shakib S, Spruijt-Metz D, Sun P, Johnson CA. Acculturation, physical activity, and fast-food consumption among asian-american and hispanic adolescents. *Journal of Community Health*. 2004; 29: 467-481
- Bodor J.N., Rice J., Farley T., Swalm C.M., Rose D. The Association between Obesity and Urban Food Environments, *Journal of Urban Health*. 2010; 87: 771-781.
- Block G, Woods M, Potosky A, Clifford C. Validation of a self-administered diet history questionnaire using multiple diet records. *J Clin Epidemiol*. 1990; 43:1327-1335.
- Subar A. Developing Dietary Assessment Tools. *J Am Diet Assoc*. 2004; 104: 769-770
- Ervin RB . Prevalence of Metabolic Syndrome Among Adults 20 Years of Age and Over, by Sex, Age, Race and Ethnicity and Body Mass Index: United States, 2003–2006 National Health Statistics Report, 2009, <http://www.cdc.gov/nchs/data/nhsr/nhsr013.pdf>
- Wajchenberg BL. Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. *Endocrine Rev*. 2000; 21: 679-738.
- Albai O, Serban V, Sima A. Prevalence of metabolic syndrome in the Timis county, *Journal of Experimental Medical & Surgical Research*. 2007; 14: 179-183
- Grundy S. Metabolic Syndrome Pandemic. Arteriosclerosis, Thrombosis and Vascular Biology. 2008; 28: 629-636
- Dorobantu M, Darabont R. O., Badila E and Ghiorghie S. - Prevalence, Awareness, Treatment, and Control of Hypertension in Romania: Results of the SEPHAR Study International Journal of Hypertension. 2010; Article ID 970694, 6 pages doi:10.4061/2010/970694
- Stevens J., and Truesdale K.P. Obesity/Fat distribution in Benjamin Caballero, Lindsay Allen & Andrew Prentice (editors). *Encyclopedia of Human Nutrition* second edition, Elsevier Academic Press, Oxford, UK. 2005; pg 392-399
- Ibrahim M.. Subcutaneous and visceral adipose tissue: structural and functional differences, *Obesity Rev*. 2010;11: 11-18, doi: 10.1111/j.1467-789X.2009.00623.x
- Boden G and Shulman G.I. Free fatty acids in obesity and type 2 diabetes: defining their role in the development of insulin resistance and cell dysfunction, *European Journal of Clinical Investigation*.2002; 32 (Suppl. 3): 14-23
- Wang ZV, Scherer PE. Adiponectin, cardiovascular function, and hypertension. *Hypertension*. 2008;51:8-14.
- Dorresteijn J.A.N., Visseren F. L. J. and Spierin W. Mechanisms linking obesity to hypertension. *Obesity Reviews*. 2012;13: 17-26
- Huang T, Kempf A, Strother M, Chaovang L, Lee R, Harris K, et al. Overweight and Components of the Metabolic Syndrome in College Students. *Diabetes Care*. 2004;27:3000-3001
- Mattsson N, Rönnemaa T, Juonala M, Viikari JS, Raitakari OT. The prevalence of the metabolic syndrome in young adults. The Cardiovascular Risk in Young Finns Study. *Journal of Internal Medicine*. 2007; 261:159-69.
- Ferreira I, Henry R, Twisk J, van Mechelen W, Kemper HC, Stehouwer CD. The Metabolic Syndrome, Cardiopulmonary Fitness, and Subcutaneous Trunk Fat as Independent Determinants of Arterial Stiffness: The Amsterdam Growth and Health Longitudinal Study, *Arch Intern Med*. 2005;165:875-882
- Soysal A, Ucku R, Soysal D. Prevalence of the metabolic syndrome in a population \geq 20 years old residing in gültepe quarter of Konak, Izmir *Eur J Int Med*, 2009: 20: S282-S283