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# Body Composition Analysis of University Students by Anthropometry and Bioelectrical Impedance Analysis

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***Abstract*—**Background: Worldwide, at least 2.8 million people die each year as a result of being overweight or obese, and 35.8 million (2.3%) of global DALYs are caused by overweight or obesity. Obesity is acknowledged as one of the burning public health problems reducing life expectancy and quality of life. The body composition analysis of the university population is essential in assessing the nutritional status, as well as the risk of developing diseases associated with abnormal body fat content so as to make nutritional recommendations. Objectives: The main aim was to determine the prevalence of obesity and overweight in University students using Anthropometric analysis and BIA methods. Material and Methods: In this cross-sectional study, 283 university students participated. The body composition analysis was undertaken by using mainly: i) Anthropometric Measurement: Height, Weight, BMI, waist circumference, hip circumference and skin fold thickness, ii) Bio-electrical impedance was used for analysis of body fat mass, fat percent and visceral fat which was measured by Tanita SC-330P Professional Body Composition Analyzer. The data so collected were compiled in MS Excel and analyzed for males and females using SPSS 16. Results and Discussion: The mean age of the male (n= 153) studied subjects was 25.37 ±2.39 years and females (n=130) was 22.53 ±2.31. The data of BIA revealed very high mean fat per cent of the female subjects i.e. 30.3±6.5 per cent whereas mean fat per cent of the male subjects was 15.60±6.02 per cent indicating a normal body fat range. The findings showed high visceral fat of both males (12.92±3.02) and females (16.86±4.98). BMI, BF% and WHR were higher among females, and BMI was higher among males. The most evident correlation was verified between BF% and WHR for female students ($r=0.902$; $p<0.001$). The correlation of BFM and BF% with thickness of triceps, sub scapular and abdominal skin folds and BMI was significant ($P<0.001$). Conclusion: The studied data made it obvious that there is a need to initiate lifestyle changing strategies especially for adult females and encourage them to improve their dietary intake to prevent incidence of non-communicable diseases due to obesity and high fat percentage.

***Keywords*—**Anthropometry, bioelectrical impedance, body fat percentage, obesity.

## I. Introduction

ALMOST all countries are facing obesity endemic, although great variation exists between and within countries. Sedentary lifestyle and high fat (high caloric) diet have increased globally as a result of industrial, urban and mechanic changes of developing countries. Improved economic status promotes the obesity and metabolic syndrome in all age groups particularly young adults. Thus, obesity is a vexing problem in the developed economies [1], [2].

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Obesity is defined as abnormal or excessive fat accumulation that may impair health. It is acknowledged as one of the burning public health problems reducing life expectancy and quality of life. It becomes the most glaring outward sign of the changing face of malnutrition in developing countries; increase the chances of a person falling prey to the other non-communicable diseases. It has been reported that with each surge in weight, there is an increase in the risk for coronary heart disease, type 2 diabetes, cancer (endometrial, breast, and colon), hypertension, dyslipidaemia, stroke, sleep apnoea, respiratory problems, osteoarthritis, and gynaecological problems as menstrual irregularities and infertility [3].

Kastorini et al. report that worldwide, at least 2.8 million people die each year as a result of being overweight or obese, and 35.8 million (2.3%) of global DALYs are caused by overweight or obesity [4]. It is predicted in 2030 globally an estimated 2.16 billion adults will be overweight, and 1.12 billion will be obese. The WHO Expert Consultation on Obesity held in 1997 warned of an escalating epidemic of obesity that would put the populations of most countries at risk of developing non-communicable diseases (NCDs) and a greater future burden of obesity and diabetes will affect developing countries, and the projected numbers of new cases of diabetes run into the hundreds of millions within the next 2 decades [5].

Blood pressure and heart diseases are found to be more than twice among overweight individuals than normal weight ones. The adult onset diabetes could be predicted and linked to childhood obesity, imposing them at risk of a wide range disorders like blindness, nerve damaging, kidney disease and cardiovascular diseases, musculoskeletal disorders, cancer, and premature death. These effects are created by the medical implications associated and precipitated by excess adiposity and weight.

Changes in diet for the past 30 years have been significant in terms of more fat, more meat, added sugars and bigger portion sizes. “Nutrition transition,” termed as a combination of improved access to food, decreased physical activity level (PAL) has been identified to be the prime risk factor for the increasing prevalence of overweight and chronic metabolic diseases in the developing countries [6]. The implications of these trends for health, quality of life, productivity, and health care costs are staggering.

Therefore, the primary goal of assessing obesity is to determine the proportion of fat mass relative to lean body mass. Fat mass comprises essential fat and storage fat, the

former being the fat necessary to sustain normal physiological function and the latter consisting primarily of adipose tissue. Lean body mass, on the other hand, includes several components, including muscle, water, bone, connective tissue and internal organs. Field techniques, include skinfolds, anthropometric measurements (e.g., body mass index [BMI], waist circumference and waist-to-hip ratio and bioelectrical impedance analysis (BIA), which are usually simpler and less expensive.

As BMI measurement is not the only predictor of obesity, other simple alternative anthropometric measures as waist circumference (WC), either alone or in combination with other anthropometric measurements is considered more useful for identifying individuals at increased cardio metabolic risk than BMI [7]-[9]. However, WC has not been widely adopted in clinical practice both because it is inconvenient for patients and health professionals, and the variability introduced by different measurement sites and imprecision of measurement leads to poor reproducibility [10]. Poor reproducibility is particularly important if dichotomous cut-points are used to define at risk groups for further assessment [11], [12].

The limitations of BMI and WC, coupled with a need for quick and accurate measurements in clinical practice, have led to renewed interest in alternative measurements of body composition, such as bioelectrical impedance analysis (BIA). BIA works by determining the electrical impedance of a small constant alternating current passing through the body [11] and can be measured by a variety of devices. Population-specific models have been created to use an individual's impedance value to estimate percentage body fat (%BF) [13], [14].

BIA is a common method used to assess body composition in healthy adults. It offers the advantages of being non-invasive and relatively easy to perform. However, because BIA is based on several assumptions regarding the human body that are inaccurate, and because it requires adherence to strict pre-test guidelines, the accuracy of the results has been questioned. To improve accuracy, BIA measurements have been taken in a fasting state after 10 minutes in a supine position. In addition to BIA, anthropometric methods such as BMI and circumference measurements appear to be suitable alternatives for assessing body composition in obese persons. These methods are not only simple but can be used to predict risk of disease and disability, which is usually a primary concern for these individuals.

## II. Material and Methods

A cross-sectional study, nested in a cohort study, was conducted in the health centre, Kurukshetra University, Kurukshetra, in September 2013. This cohort study is prospective in nature and, aiming to determine the prevalence of obesity and overweight in University students using Anthropometric analysis and BIA methods. A total of 283 university students, 153 males and 130 females participated. The body composition analysis was undertaken by using mainly:

i) Anthropometric Measurement: Height, Weight, BMI, waist circumference, hip circumference and skin fold thickness

The height was taken barefoot in centimetres using a stadiometer. It was recorded to the nearest 1cm. The weight was measured in kilogram without shoes using Omron weighing machine having precision of 0.5 kg. Checks on the scale were made routinely before recording the weight of each student and the pointer was adjusted to zero using the screw provided. The body weight was recorded when the display of the body weight became stabilized. The BMI defined as weight (kg)/ height (m)² was used to assess the nutritional status of the subjects. If an individual has a BMI from 25 to less than 30, he or she is overweight. Having a BMI of 30 or more means an individual is obese. The risk of chronic diseases has been reported to increase as BMI escalated resulting in obesity. Thresholds of body mass index (BMI) are used worldwide to identify people who are normal weight, overweight or obese. Although it is recognised that obesity, defined by a BMI $\geq$30 kg/m$^2$, is a cause of impaired health and disease, BMI does not provide information on fat mass or percentage, or fat distribution. Along with this other indices, such as waist and hip circumference measure different aspects of body composition and fat distribution which have independent and often opposite effects on cardiovascular disease risk factors [15]. Waist circumference is a relatively simple and convenient measure and can be used to assess the quantity of abdominal fat. Hip measurements provide additional valuable information about gluteofemoral muscle mass and bone structure [16] hip circumference is negatively associated with health outcomes in women [17]. The waist- to-hip ratio (WHR) may therefore be a useful measure, since it also includes the accumulation of fat on the hips; such an accumulation may be beneficial for health [15].

Skinfold measurement was obtained using a Lange Skinfold Callipers, with a 0-60 mm scale, 1 mm accuracy and three repetitions. The sum of the four skinfolds (BSF, TSF, Sub scapular and abdominal fat enabled the indirect calculation of percentage body fat and body fat (%GC) and body fat in kilograms (Kg) [18]. Skinfold measurement is most popular because of the method's low cost and practicality [19].

ii) Bio-electrical impedance was used for analysis of body fat mass, fat percent and visceral fat which was measured by Tanita SC-330P Professional Body Composition Analyzer. The data so collected were compiled in MS Excel and analyzed for males and females using SPSS 16.

## III. Results and Discussion

Of the 283 subjects in the study, 153 (56.42%) were males and 130 (46.42%) were females. The mean age of the male studied subjects was 25.37±2.39 years and females (n=130) was 22.53 ±2.31. The data revealed that mean normal weight of males was 57.6±5.4 and of females was 52.0±3.8 Kg. Almost 52 per cent subjects were deemed normal weight. Body weight reflects height and body composition, which comprises lean body mass (muscle, bone and water) and fat

(adipose tissue). Gibson opines that weight is a better indicator of short-term nutritional status, whereas height reflects longer term nutritional status. If the weight centile is substantially lower than the height centile, this difference may indicate acute nutritional problems [20].

BMI is considered to be a gauge of obesity and fitness in various cultures and narrates incidence and prevalence of obesity with regard to mortality and morbidity rates in ethnic populations [21]. From the studied data, it was observed that according to BMI classification, 34 (12.14%) subjects turned out to be underweight, 80 (28.42%) as overweight and 75 (26.57%) were obese. Maximum number of male students (90.76%) was found to be normal weight whereas only 42.11 per cent females were normal weight (Table I).

TABLE I
DISTRIBUTION OF SUBJECTS ON THE BASIS OF BODY WEIGHT AND BMI

| Parameters | | N | Underweight | | Normal Weight | | Overweight | | Obese | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Per Cent | Mean ±S.D. | Per Cent | Mean ±S.D. | Per Cent | Mean ±S.D. | Per Cent | Mean ±S.D. |
| Weight (Kg) | Male | 153 | 0.89 | 49.3±9.5 | 69.05 | 57.6±5.4 | 11.89 | 63.1±5.3 | 17.37 | 69.2±6.8 |
| | Female | 130 | 7.98 | 40.2±6.8 | 46.72 | 52.0±3.8 | 24.26 | 58.4±3.8 | 21.04 | 63.1±4.2 |
| BMI | Male | 153 | 2.08 | 16.4±1.5 | 90.76 | 22.8±2.6 | 4.01 | 27.3±2.9 | 3.15 | 38.8±6.9 |
| | Female | 130 | 10.06 | 15.7±2.8 | 42.11 | 20.6±4.7 | 24.41 | 26.4±1.5 | 23.42 | 35.3±7.1 |

TABLE II
DISTRIBUTION OF SUBJECTS ON THE BASIS OF BODY FAT, BODY FAT % AND VISCERAL FAT MEASURED BY BIO ELECTRICAL IMPEDANCE

| Parameters | | N | Underweight | | Normal Weight | | Overweight | | Obese | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Per Cent | Mean ±S.D. | Per Cent | Mean±S.D. | Per Cent | Mean±S.D. | Per Cent | Mean ±S.D. |
| Body Fat | Male | 153 | 1.78 | 43.7±11.2 | 64.09 | 55.1±4.3 | 14.82 | 58.9±6.4 | 19.31 | 64.4±2.9 |
| | Female | 130 | 17.95 | 41.6±2.4 | 11.54 | 57.5±3.9 | 46.42 | 68.1±5.8 | 24.09 | 72.8.±15.9 |
| Body Fat% | Male | 153 | 8.96 | 13.6±3.0 | 58.84 | 16.8±3.5 | 18.73 | 21.0±6.6 | 13.47 | 29.9±5.2 |
| | Female | 130 | 21.53 | 18.3±3.7 | 23.07 | 26.7±5.8 | 32.33 | 32.5±2.6 | 23.07 | 35.7±4.2 |
| Visceral Fat | Male | 153 | 19.63 | 5.92±3.02 | 48.02 | 6.3±3.1 | 20.61 | 10.5±2,9 | 11.74 | 18.2±5.4 |
| | Female | 130 | 36.84 | 4.86±4.98 | 24.85 | 7.6±2.2 | 16.85 | 19.4±3.7 | 21.46 | 16.3±6.8 |

TABLE III
WAIST AND HIP RATIO OF UNIVERSITY STUDENTS

| Parameter | | Min. | Max. | Mean± S.D. |
|---|---|---|---|---|
| Waist Circumference (cm) | Male | 73.6 | 135.7 | 94.8±11.2 |
| | Female | 61.2 | 105.8 | 73.5±10.5 |
| Hip Circumference (cm) | Male | 92.5 | 148.1 | 113.4±7.7 |
| | Female | 83.9 | 131.7 | 102±16.1 |
| Waist-to-Hip Ratio | Male | 0.79 | 0.91 | 0.7±0.15 |
| | Female | 0.72 | 0.79 | 0.6±0.9 |

TABLE IV
CORRELATION BETWEEN ANTHROPOMETRIC CHARACTERISTICS

| Groups | | BMI | BF% | BFM | WHR | Triceps | Biceps | Sub scapular | Abdominal |
|---|---|---|---|---|---|---|---|---|---|
| Males | BMI | 1 | 0.79 | 0.76 | 0.65 | 0.63 | 0.68 | 0.65 | 0.63 |
| | BF% | 0.73 | 1 | 0.68 | 0.62 | 0.83* | 0.75 | 0.88* | 0.85* |
| | BFM | 0.62 | 0.69 | 1 | 0.57 | 0.87* | 0.67 | 0.84* | 0.89* |
| | WHR | 0.55 | 0.78 | 0.67 | 1 | 0.65 | 0.56 | 0.74 | 0.73 |
| | Triceps | 0.49 | 0.65 | 0.69 | 0.62 | 1 | 0.49 | 0.68 | 0.59 |
| | Biceps | 0.48 | 0.58 | 0.59 | 0.37 | 0.57 | 1 | 0.70 | 0.48 |
| | Sub scapular | 0.68 | 0.45 | 0,49 | 0.31 | 0.48 | 0.53 | 1 | 0.55 |
| | Abdominal | 0.64 | 0.73 | 0.73 | 0.69 | 0.62 | 0.58 | 0.68 | 1 |
| Females | BMI | 1 | 0.69 | 0.69 | 0.58 | 0.60 | 0.61 | 0.69 | 0.56 |
| | BF% | 0.63 | 1 | 0.66 | 0.90* | 0.86* | 0.46 | 0.81* | 0.87* |
| | BFM | 0.68 | 0.70 | 1 | 0.56 | 0.82* | 0.37 | 0.80* | 0.89 * |
| | WHR | 0.59 | 0.68 | 0.63 | 1 | 0.38 | 0.40 | 0.79 | 0.78 |
| | Triceps | 0.47 | 0.38 | 0.44 | 0.43 | 1 | 0.34 | 0.60 | 0.74 |
| | Biceps | 0.50 | 0.33 | 0.47 | 0.38 | 0.39 | 1 | 0.57 | 0.49 |
| | Sub scapular | 0.61 | 0.47 | 0.52 | 0.42 | 0.44 | 0.41 | 1 | 0.51 |
| | Abdominal | 0.77 | 0.65 | 0.71 | 0.54 | 0.62 | 0.59 | 0.68 | 1 |

*Correlation is significant at the 0.01 level

There is no single ideal percentage of body fat for everyone. Levels of body fat are epidemiologically dependent on sex and age [22]. Different authorities have developed different recommendations for ideal body fat percentages. It is a measure of fitness level, since it is the only body measurement which directly calculates a person's relative body composition without regard to height or weight. Here, the Body Fat% classification emphasises, 28 (21.53%) female subjects were underweight, 30 (23.07%) normal weight, 42 (32.31%) were overweight and 30 (23.07%) were obese whereas only 18.73 per cent male subjects were overweight and 13.47 per cent were obese. The body fat per cent of a human or other living being is the total mass of fat divided by total body mass; body fat includes essential body fat and storage body fat. Essential body fat is necessary to maintain life and reproductive functions. The percentage of essential body fat for females is greater than that for males, due to the demands of childbearing and other hormonal functions. The average fat per cent is 8-19.9 per cent in males and 21–32.9 per cent in females of age 20-39 years [23]. Fat per cent below the average is associated with malnutrition and above average may lead to diseases associated with obesity. Many studies have found that high BF% was associated with increased cardiovascular risk regardless of BMI whose categorisation resulted in an underestimation of subjects with cardiovascular risk factors [24]-[26]. It was observed that a higher percentage of females were obese [24.09%, 23.07%, 21.46%] as compared to their male [19.31%, 13.47%, 11.74%) counterparts on the basis of BFM, BF % and visceral fat respectively as indicated in Table II.

Visceral fat, or abdominal fat, is a type of body fat that exists in the abdomen and surrounds the internal organs. Everyone has some, especially those who are sedentary, chronically stressed, or maintain unhealthy diets have high levels of visceral fat. In fact, excessive deposits of visceral fat are thought to be closely linked to increased levels of fat in the bloodstream, which can lead to common diseases such as hyperlipidemia and diabetes, that impairs the ability of insulin to transfer energy from the bloodstream and using it in cells. In order to prevent or improve conditions of common diseases, it is important to try and reduce visceral fat levels to an acceptable level. People with high visceral levels tend to have large stomach. However, this is not always the case and high visceral fat levels can lead to metabolic obesity. Metabolic obesity (visceral obesity with normal weight) represent fat levels that are higher than average, even if a person's weight is at or below the standard for their height. The data reveals that mean visceral fat of overweight male and female subjects were 10.5±2.9 and 19.4±3.7 respectively. Whereas, mean visceral fat of obese male subjects was observed 18.2±5.4 and of female subjects was 16.3±6.8.

Table III depicts that male subjects have a waist circumference of 94.8±11.2, hip circumference of 113.4±7.7 and waist-to-hip circumference ratio 0.7±0.15, while females waist-to-hip circumference ratio was 0.6±0.9 with mean waist circumference 73.5±10.5 and mean hip circumference 102±16.1. The difference in the prevalence of obesity based on body fat percent was statistically significant between males and females

As shown in Table IV, the most evident correlation was verified between BF% and WHR for female students ($r=0.902$; $p<0.001$). The correlation of BFM and BF% with thickness of triceps, sub scapular and abdominal skin folds and BMI was highly significant ($P<0.001$). Amani reported a similar correlation between BF% and BFM obtained from BIA method and BMI ($r=0.86$ and 0.77 respectively) [27]. Females have a higher amount of body fat than men. In another investigation by Pecoraro et al. a significant correlation was detected between BFM measured by BIA and BMI ($r=0.92$) [28].

It is opined that further research into the value of %BF measured by BIA as a marker of metabolic health would be beneficial.

## IV. Conclusion

The studied data made it obvious that there is a need to initiate lifestyle changing strategies especially for adult females and encourage them to improve their dietary intake to prevent incidence of non-communicable diseases due to overweight, obesity and high fat percentage. More research is needed in this area. A continued analysis of increasing body fat trends of university and college students is needed to determine the health risks of the population. In addition, an in depth look into how and why students set their nutrition and physical activity goals would give greater insight into the types of programs that could be developed to improve their nutritional and health status.

## References

[1] Stein CJ, Colditz GA. The epidemic of obesity. J Clin Endocrinol Metab. 2004;89:2522–5. (PubMed)

[2] Lau DC. The Obesity Canada Clinical Practice Guidelines Steering Committee and Expert Panel. Synopsis of the 2006 Canadian clinical practice guidelines on the management and prevention of obesity in adults and children. Can Med Assoc J. 2007;176: 1103–6. (PMC free article) (PubMed).

[3] Centers for Disease Control and Prevention, "Overweight and obesity 2012, http://www.cdc.gov/obesity/adult/causes/index.html.

[4] Kastorini CM, Milionis HJ, Ioannidi A, et al. Adherence to the Mediterranean diet in relation to acute coronary syndrome or stroke nonfatal events: A comparative analysis of a case/case-control study. Am Heart J. 2011;162:717–724. (PubMed)

[5] WHO. *Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. WHO Technical Report Series No. 894*. Geneva: World Health Organisation, 2000.

[6] D. J. Hoffman, "Upper limits in developing countries: warning against too much in lands of too little," Journal of the American College of Nutrition, vol. 23, no. 6, pp. 610S–615S, 2004. View at Google Scholar • View at Scopus

[7] de Koning L, Merchant AT, Pogue J, Anand SS (2007) Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. Eur Heart J 28: 850–856. doi: 10.1093/eurheartj/ehm026

[8] Krakauer NY, Krakauer JC (2014) Dynamic association of mortality hazard with body shape. PLOS ONE 9: e88793. doi: 10.1371/journal.pone.0088793

[9] Stevens J, McClain JE, Truesdale KP (2008) Selection of measures in epidemiologic studies of the consequences of obesity. Int J Obes (Lond) 32: Suppl 3, S60–66. doi: 10.1038/ijo.2008.88

[10] Brown P (2009) Waist circumference in primary care. Prim Care Diabetes 3: 259–261. doi: 10.1016/j.pcd.2009.09.006

[11] Mason C, Katzmarzyk PT (2009) Variability in waist circumference measurements according to anatomic measurement site. Obesity 17: 1789–1795. doi: 10.1038/oby.2009.87
[12] Lee SY, Gallagher D (2008) Assessment methods in human body composition. Curr Opin Clin Nutr Metab Care 11: 566–572.
[13] Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, et al. (2004) Bioelectrical impedance analysis-part II: utilization in clinical practice. Clin Nutr 23: 1430–1453. doi: 10.1016/j.clnu.2004.09.012
[14] Ricciardi R, Talbot LA (2007) Use of bioelectrical impedance analysis in the evaluation, treatment, and prevention of overweight and obesity. J Am Acad Nurse Pract 19: 235–241. doi: 10.1111/j.1745-7599.2007.00220
[15] Avenell A, Broom J, Brown TJ, Poobalan A, Aucott L, Stearns SC, Smith WC, Jung RT, Campbell MK and Grant AM. Systematic review of the long-term effects and economic consequences of treatments for obesity and implications for health improvement. Health Technol Assess. 2004; 8:iii-iv, 1-182. | PubMed Abstract | PubMed Full Text
[16] Merten S, MPH and Julia Dratva, et al. Do baby-friendly hospitals influence breastfeeding duration on a national level?. Pediatrics. 2005; 116:702–708. | Article.
[17] Bosy-Westphal A, Booke CA, Blocker T, Kossel E, Goele K, et al. (2010) Measurement site for waist circumference affects its accuracy as an index of visceral and abdominal subcutaneous fat in a Caucasian population. J Nutr 140: 954–961. doi: 10.3945/jn.109.118737
[18] Siri W.E. Body composition from fluid spaces and density analysis of methods. In: Brozek J, Henschel A.Techniques for measuring body composition. Washington, DC: National Research Council; 1961. p. 223-44.
[19] Lee S.Y., Gallagher D. Assessment methods in human body composition. Curr Opin Clin Nutr Metab Care. 2008;11(5):566–572. (PMC free article) (PubMed).
[20] Gibson R.S. Food and Nutrition Guidelines for Healthy Children and Young People (Aged 2–18 years): A background paper. Principle of nutritional assessment (2nd ed.) Oxford: Oxford University Press, 2005: 20-30.
[21] Flegal KM, Graubard B I, Williamsen D F, Mitchell G H. Excess deaths associated with underweight, overweight, and obesity. JAMA 2005; 293: 1861-67.
[22] Jackson AS, Stanforth PR, Gagnon J, Rankinen T, Leon AS, Rao DC, et al. The effect of sex, age and race on estimating percentage body fat from body mass index: the heritage family study. Int J Obes Relat Metab Disord 2002; 26: 789-96.
[23] Gallagher D., Heymsfield S. B., Heo M., Jebb S. A., Murgatroyd P. R., and Sakamoto Y.,. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index1–3. Am. J. Clin. Nutr., September 2000; 72 (3): 694-701.
[24] Zeng Q, Dong SY, Sun XN, Xie J, Cui Y. Percent body fat is a better predictor of cardiovascular risk factors than body mass index. Braz J Med Biol Res 2012; 45: 591-600.
[25] Gómez-Ambrosi J, Silva C, Galofré JC, Escalada J, Santos S, Millán D, et al. Body mass index classification misses subjects with increased cardiometabolic risk factors related to elevated adiposity. Int J Obes (Lond) 2012; 36: 286-94.
[26] Chris Burslem, October. The Changing Face of Malnutrition. IFPRI Forum, International Food Policy Research Institute: Washington, D.C. 2004. | Pdf*Fuzzy Sets and Systems*. Vol. 49, No. 1, 1992.
[27] Amani R. Comparison between bioelectrical impedance analysis and body mass index methods in determination of obesity prevalence in Ahvazi women. Eur J Clin Nutr. 2007;61:478–82. (PubMed).
[28] Pecoraro P, Guida B, Caroli M, et al. Body mass index and skinfold thickness versus bioimpedance analysis: fat mass prediction in children. Acta Diabetol.2003; 40:S278–81. (PubMed).