International Journal of Research in Medical Sciences
Dube S et al. Int J Res Med Sci. 2016 Nov;4(11):4806-4811
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20163770

Original Research Article

Observational study of body weight, body fat with segmental fat distribution, visceral fat and body mass index in type 2 diabetic patients

Sunil Dube[1], Shanti Viswanathan[2]*, Manjree Dube[2]

[1]Department of Medicine, Somaiya Medical College, Mumbai, Maharashtra, India
[2]Department of Physiology, M.G.M Medical College, Navi Mumbai, Maharashtra, India

Received: 23 August 2016
Accepted: 26 September 2016

***Correspondence:**
Dr. Shanti Viswanathan,
E-mail: shanti_srini@hotmail.com

ABSTRACT

Background: There has been an increase in the prevalence of non-communicable diseases in the last decade. This prevalence has been steadily increasing and is expected to increase further in the coming decade. The change in our lifestyle plus a sedentary lifestyle has led to this .Various body composition monitoring methods help us evaluate obesity and its association with diabetes. In this study, we analysed the trend of body fat distribution in diabetics.
Methods: A multifrequency body composition monitor TANITA MC 980 was used to analyse visceral fat, body fat and segmental fat distribution. This was correlated with BMI.
Results: BMI showed a significant correlation between body fat (R^2=0.558) and visceral fat (R^2=0.166) where R>0.5 is significant. BMI showed a negative correlation with upper and lower body adiposity. Linear regression analysis also showed a positive relation between BMI and visceral fat and BMI and body fat. The overall accuracy of body fat and visceral fat to assess obesity was 0.829 and 0.731 respectively.
Conclusions: This study showed a positive correlation between BMI and visceral fat as well as body fat as measured by bioelectric impedance method. Visceral fat being a definite risk factor for development of Type 2 diabetes and its association with other comorbidities, there is a need not only to measure body fat but also visceral fat in type 2 diabetes.

Keywords: Body mass index, Bioimpedance analysis, Body fat, Visceral fat

INTRODUCTION

There is an increasing prevalence of type 2 Diabetes Mellitus in India and developing countries. In the last 10-15 years, this rise of non-communicable diseases has been attributed to the changing socioeconomic status, dietary habits and urbanization.[1]

Also the prevalence of diabetes varies among ethnic groups. There is also a link between Diabetes and Obesity which appears to be synergistic. WHO has defined obesity as a condition with excessive fat accumulation in the body to the extent that health and well-being are affected.[2] India has emerged as the Diabetes capital due to this strong association. Obesity being an established risk factor for NIDDM, measurement of obesity becomes important to assess body composition and its relation to the development of progression of diabetes.

Body composition monitoring gives an insight into health indicators. It sets a target for individual physique and monitors progress towards it. Numerous methods and equipment are available to assess fat and other components of body composition. Body composition methodology is based on assumptions regarding density of body tissues, water and electrolyte concentrations and biological interrelationships between body composition, body tissues and their distribution among normal weight individuals.[3] The application of body composition technology is limited among obese adults and older obese children because their bodies exceed limitations of available equipment. There are many methods of assessing body composition like near infrared interactance, hydrodensitometry, Dual X ray absorptiometry, Bioelectrical impedance analysis, Total body electrical conductivity and anthropometric methods.[4]

The term anthropometric refers to measurements made of various parameters of the body such as height, weight, waist to hip ratio, thickness of skin folds. Anthropometric methods are the simplest ways of assessing body composition. BMI is the most commonly used weight for height index. It is measured using height and weight of the individual. Other anthropometric methods are waist circumference, waist to hip ratio and subscapular thickness.[5] Studies have shown a good correlation between the different anthropometric methods and the prediction of obesity.[6]

Bioelectrical impedance has now emerged as a promising tool for estimating body composition. Many studies have shown its validation as a screening mehod.[7] BIA has shown to provide results as accurate as hydrodensito metry and Dual Xray absorptiometry.[8] BIA works on the principle of opposition of body tissues to the flow of a small (less than 1mA) alternating current.[9] BIA uses single frequency current. But recently BIA using multiple frequency has shown to provide more accurate results.[10,11]

BIA produces estimates of fat free mass and fat mass by measuring the resistance of the body as a conductor to a very small alternating current. BIA has emerged as a promising technique because of its simplicity, low cost, high reproductibility and patient acceptability.[12] Studies in type-1 Diabetes have recently been published validating it in this group. However the vast majority have type 2 DM who have obesity in 85% individuals. Hence use of BIA in body composition measurement would be of interest both for clinical and investigative purposes.

In this study, We analysed the trend of obesity in diabetics on the basis of body mass index. Then BMI was correlated with the amount of body fat, segmental fat distribution and visceral fat based on the principle of BIA.

METHODS

Tanita MC 980 is a multifrequency body composition monitor designed to analyze body weight and composition. It uses multifrequency 50 Hz leg to leg bioimpedance analysis for standing impedance and body weight measurement. Safe low level electrical signals are passed through the body via the patented TANITA foot pads on the monitor platform. It is easy for the signal to flow through fluids in the muscle and other body tissues but meets resistance as it passes through body fats as it contains little fluid. This resistance is called impedance.

The impedance readings are then entered into medically researched mathematical formulas to calculate the body composition. The advantages of using Tanita machine is that it differentiates between fat and lean mass. It gives highly predictive values and is sensitive enough to detect clinically important differences. It is simple, fast and highly suitable for large scale health surveys. The impedance was used to calculate the Total body water. Then fat free mass was calculated from total body water. Fat mass was then calculated as the difference between body weight and fat free mass and relative body fat was calculated accordingly. Determination of fat free mass assumes a constant hydration level of 73% in individuals.

Variables that affect the measurements include body position, hydration status, consumption of food and beverages, recent physical activity and menstrual cycle. Accordingly these factors were considered. 211 Diabetic people were recruited for this study after taking approval from the Ethical committee. Proper informed consent was taken. They were instructed to refrain from alcohol and strenuous physical activity 24hrs prior to the study.

Exclusion criteria

- Persons with an electronic pacemaker.
- Pregnant women.
- After strenuous exercise
- People with illness and infection
- After alcohol consumption
- Poor hydration status

Precautions

- All the fingers were in contact with electrodes
- Feet were in contact with all the electrodes
- Arms were extended and elbows were not in touch with body
- The knees were not bent.

The unit was turned on. Personal data number was selected. The subject's height was specified and SET was pressed to confirm. When 0.0 was displayed the hand electrode was held. The readings were then recorded. The unit was switched off. The data was analysed using pearson correlation and linear regression analysis.

RESULTS

A total of 211 patients were recruited for the study after taking proper informed consent out of which 121 were males and 90 were females. In the present study we studied the trend of body composition in type 2 Diabetics.

Accordingly we classified individuals as normal (18.5-24.9), overweight (>25), pre-obese (25-29.9) and obese (>30) on the basis of WHO classification of BMI. Out of 121 males 50 had normal BMI, 11 were overweight, 43 were pre-obese and 17 were obese.

Table 1: Descriptive statistics.

BMI- category	Gender	Number		Body Fat	Visceral Fat	RUL	RLL	LLL	LUL
Normal	Male	50	Mean	24.108	10.480	17.852	21.366	21.834	17.256
			SD	5.015	3.683	9.259	6.768	7.006	6.610
	Female	20	Mean	33.715	6.900	28.235	32.525	32.105	28.055
			SD	3.497	1.651	4.331	4.579	8.015	7.535
Overweight	Male	11	Mean	27.973	14.455	19.782	24.955	25.618	20.827
			SD	3.618	2.945	4.414	5.025	5.822	4.450
	Female	7	Mean	36.400	9.571	30.143	31.943	34.886	31.371
			SD	4.350	4.158	8.210	10.939	5.495	7.977
Pre-Obese	Male	43	Mean	30.619	13.256	23.800	28.558	28.281	24.367
			SD	6.041	3.506	7.916	7.263	7.889	8.549
	Female	28	Mean	40.046	10.107	35.475	37.971	37.493	36.411
			SD	3.968	3.224	5.587	4.994	5.961	6.596
Obese	Male	17	Mean	37.306	17.353	30.629	34.347	33.935	30.712
			SD	6.262	3.278	10.342	8.500	7.892	11.423
	Female	35	Mean	45.754	12.000	41.580	41.237	40.654	41.237
			SD	5.777	2.142	8.233	8.263	8.174	10.734

Table 2: Linear regression analysis.

Coefficients[a]					
	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	9.149	0.825		11.094	0.000
Visceral_Fat	0.563	0.038	0.531	14.983	0.**000**
RUL	0.053	0.030	0.142	1.790	0.075
RLL	0.064	0.046	0.148	1.386	0.167
LLL	-0.032	0.041	-0.074	-0.774	0.440
LUL	0.050	0.046	0.137	1.071	0.286
Body_Fat	0.225	0.041	0.478	5.459	**0.000**

[a] Dependent Variable: BMI.

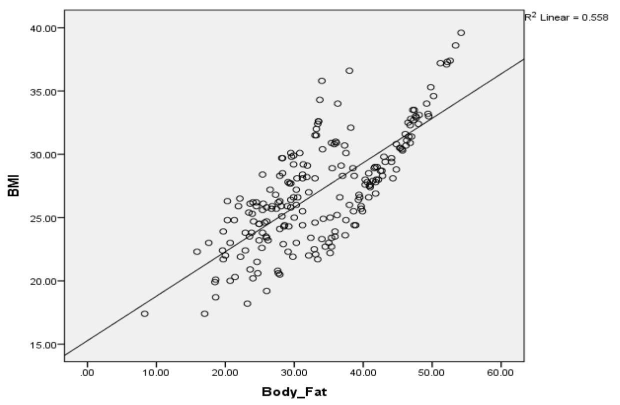

Figure 1: Scatter diagram showing the relation between BMI and body fat.

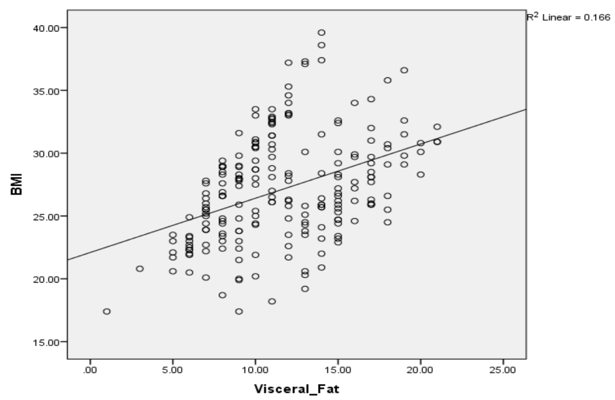

Figure 2: Scatter diagram showing the relation between BMI and visceral fat.

Out of 90 females, 20 had normal BMI, 7 were overweight, 28 pre-obese and 35 obese. Table 1 shows the descriptive statistics of the following variables. Pearson correlation showed a significant positive correlation between BMI (R^2= 0.558) and body fat and BMI and visceral fat. (R^2=0.166) where R>0.5 is significant.

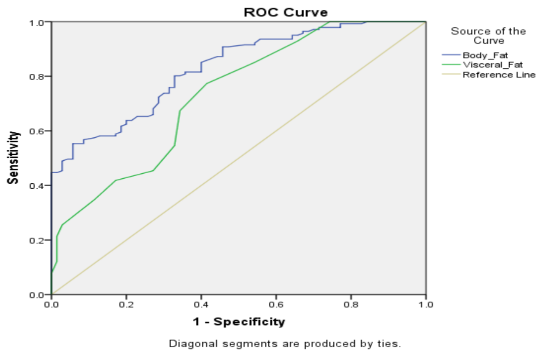

Figure 3: ROC curve.

This shows that as the body fat and visceral fat increases the BMI also increases. BMI showed a negative correlation with upper and lower body adiposity. Table 2 shows the linear regression analysis which was performed to test the relation between the dependent variable and the other independent variables. Visceral fat (0.000) and body fat (0.000) showed a positive correlation with BMI.

Receiver operating characteristics analysis was carried out to assess the sensitivity and specificity of body fat and visceral fat as an index of obesity .The probability of classifying a true obese person as obese is taken as the sensitivity and the probability of classifying a truly non obese person as non-obese is taken as specificity. The sensitivity of body fat was 97.2% and specificity was 70% respectively corresponding to a cut off value of 23.55%.This shows that body fat would classify a person as obese 97.2% of the time but will misclassify them as obese 2.8% of the time.

Table 3: Area under the curve.

Test result variable (s)	Area	Std. error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence interval	
				Lower bound	Upper bound
Body_Fat	0.829	0.028	0.000	0.775	0.884
Visceral_Fat	0.731	0.037	0.000	0.658	0.804

The sensitivity of visceral fat was 92.9% and specificity was 65.7% corresponding to a cut off value of 7.5%. This shows that visceral fat would classify a person as obese 92.9% of the time and misclassify them 7.1%of the time. Sensitivity was plotted against 1-specificity as ROC graph. The area under the curve in Figure 3 reflects the overall accuracy of body fat and visceral fat to evaluate obesity. The area under the curve is 0.829 for body fat and 0.731 for visceral fat (AUC>0.6 is significant).

DISCUSSION

In the present study we studied the trends of body composition based on BMI, body fat and visceral fat using the principle of BIA. We used the WHO classification of BMI.[13] Accordingly, 35 percent of males were overweight and 17% obese and 31% females were overweight and 38% obese. Limitations of BMI include overestimation of body fat in muscular people. BMI does not differentiate between fat and fat free mass.[14] Also the mean age of the population under study is 55 years and BMI could change with age due to the loss of muscle mass and increase in adipose tissue.

Body fat is the percentage of body fat in relation to total weight and is generally expressed as a percentage. Body fat is of two types, subcutaneous and visceral fat. As we age the amount of subcutaneous fat remains constant but the visceral fat goes on increasing. American Council on Exercise has set standards for body fat according to age and sex as 25%for males and 31% for females. The difference in the standards for men and women is because for the same age women generally have more adipose tissue due to hormonal changes, sexual organs and ovulation. On the basis of body fat, 68% of males and 90% of females were obese.

There are gender differences in body fat distribution. Men generally have an android type of obesity with more fat around the abdomen and increased visceral fat. Women have more fat in the gluteal region and therefore the gynaecoid type of obesity. They also have more amount of subcutaneous fat. Women have a lower rate of basal fat oxidation contributing to higher fat storage.[15]

In this study, BMI showed a positive relation with body fat and visceral fat. This explains that as body fat increases the BMI also increases. Visceral fat is generally more metabolically active and breaks down easily. There is a strong relation between visceral fat, physical activity and metabolic syndrome. As we age the amount of visceral fat increases and is directly proportional to the amount of physical activity the person undertakes.

Studies have shown that increased physical activity is associated with decrease in the visceral fat.[16] Visceral fat is also directly related to the development of metabolic syndrome. This association of visceral fat with metabolic syndrome is not only seen in Asians but it is also seen in other ethnic groups.[17] Visceral adipose tissue releases free fatty acids and inflammatory proteins like adipokines into the portal vein and then to the liver.

This causes an increase in intrahepatic triglycerides. This causes hepatic insulin resistance and increased hepatic gluconeo-genesis.[18]

Visceral adipose tissue also secrete substances like visfatin and omentin which alter glucose and lipid metabolism. Free fatty acids also cause insulin mediated vasodilation, endothelial dysfunction explaining the association of hypertension with diabetes. Increased free fatty acids also contribute to increased peripheral resistance of muscle to glucose entry.[19]

In this study, BMI showed no correlation with upper body adiposity and lower body adiposity. But studies show that upper limb adiposity is more correlated with risk of development of diabetes than lower body adiposity.[20]

This is because leg FFA release is much more readily suppressed than upper body subcutaneous fat in response to a meal. There are also differences in amount of FFA released from upper body visceral fat than gluteal fat with the former giving rise to increased concentration of FFA in response to a meal.[22] This explains a stronger predisposition of males to insulin resistance. Estrogen also has a protective effect by reducing the amount of catecholamine induced lipolysis.[15,21]

CONCLUSION

This study showed a positive correlation between BMI and visceral fat as well as body fat as measured by bioelectric impedance method. In this study, Receiver operative analysis showed the overall accuracy of body fat and visceral fat to classify obesity. Studies have shown that bioelectrical impedance gives as accurate a result as Dual X-ray absorptiometry and hydrodensitometry. Also bioelectrical impedance with multi-frequency has been shown to be superior to single frequency in evaluating obesity.

The main pathophysiology of Diabetes is the high amount of FFA causing insulin resistance and this can explain the gender differences in the occurrence of diabetes based on fatty acid metabolism and uptake. This should be taken up as a cohort study retrospectively to identify the individuals at high risk for developing metabolic syndrome and diabetes.

This is important not only to prevent the occurrence of diabetes but also as a source of primary prevention to prevent it from spreading as an epidemic. This would especially be useful with the change in lifestyle, dietary habits in the younger generation. They need to be counseled about the prediabetic era where there is impaired glucose tolerance and it can be prevented by appropriate lifestyle management. The drawbacks of this study is that BIA though used widely there are discrepancies on the international standards as it is based on the amount of TBW.

The amount of TBW increases with the amount of adiposity as 15to 30% of TBW is present in the adipose tissue. Also BIA is affected by the amount of body fat, age and ethnic differences in the arm span proportion. Hence population specific equations need to be developed. Hence future research needs to be done validating BIA population wise.

ACKNOWLEDGEMENTS

Authors would like to express his sincere gratitude to all the patients who have participated in this study.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27(5):1047-53.
2. James PT. Obesity: The worldwide epidemic. Clin Dermatol. 2004;22:276-80.
3. Chumlea WC. Body Composition Assessment of Obesity Departments of Community Health and Pediatrics, Lifespan Health Research Center, Wright State University School of Medicine, Dayton, OH 45420, USA. 26:23-35.
4. Wells JCK, Fewtrell MS. Measuring body composition. Arch Dis Child. 2006;91(7):612-7.
5. Duren DL, Sherwood RJ, Czerwinski SA, Lee M, Choh AC, Siervogel RM, et al. Body Composition Methods: Comparisons and Interpretation. J Diabetes Sci Technol. 2008;2(6):1139-46.
6. Pelegrini A, Silva DSA, Silva GMLF, Grigollo L, Petroski EL. Anthropometric indicators of obesity in the prediction of high body fat in adolescents. Rev Paul Pediatr. 2015;33(1):56-62.
7. Roubenoff R. Applications of bioelectrical impedance analysis for body composition to epidemiologic studies. A J Clin Nutri. 1996;64(3):459S-62S.
8. Lukaski HC, Bolonechuk WW, Hall CB, Siders WA. Validation of the bioelectrical impedance method to assess human body composition. J Appl Physiol. 1987; 60:1327-32.

9. Rutherford WJ, Gary DA, Eric SD. Comparison of Bioelectrical Impedance and Skinfolds with Hydro-densitometry in the Assessment of Body Composition in Healthy Young Adults. ICHPER-SD J Res. 2011;6(2):56-60.
10. Accuracy of direct segmental multi-frequency bioimpedance analysis in the assessment of total body and segmental body composition in middle-aged adult population. Clin Nutr. 2011;30(5):610-5.
11. Demura S, Sato S, Kitabayashi T. Percentage of total body fat as estimated by three automatic bioelectrical impedance analyzers. J Physiol Anthropol Appl Human Sci. 2004;23(3):93-9.
12. Bioelectrical Impedance Analysis in Body Composition Measurement National Institutes of Health Technology Assessment Conference Statement. 1994.
13. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157-63.
14. Dudeja V, Misra A, Pandey RM, Devina G, Kumar G, Vikram NK. BMI does not accurately predict overweight in Asian Indians in northern India. Br J Nutr. 2001;86(1):105-12.
15. Blaak E. Gender differences in fat metabolism. Clin Nutr Metab Care. 2001;4(6):499-502.
16. Saelens BE, Seeley RJ, van Schaick K, Donnelly LF, O'Brien KJ. Visceral abdominal fat is correlated with whole-body fat and physical activity among 8-y-old children at risk of obesity. Am J Clin Nutr. 2007;85(1):46-53.
17. Sandeep S, Gokulakrishnan K, Velmurugan K, Deepa M, Mohan V. Visceral & subcutaneous abdominal fat in relation to insulin resistance & metabolic syndrome in non-diabetic south Indians. Indian J Med Res. 2010;131:629-35.
18. Klein S. Is Visceral Fat Responsible for the Metabolic Abnormalities Associated With Obesity? Diabetes Care. 2010;33(7):1693-4.
19. Jensen MD. Role of Body Fat Distribution and the Metabolic Complications of Obesity. J Clin Endocrinol Metab. 2008;93(11 Suppl 1):S57-63.
20. Haffner SM, Stern MP, Hazuda HP, Pugh J, Patterson JK. Do upper-body and centralized adiposity measure different aspects of regional body-fat distribution? Relationship to non-insulin-dependent diabetes mellitus, lipids, and lipoproteins. Diabetes. 1987;36(1):43-51.
21. Wattanapenpaiboon N, Lukito W, Strauss BJ, Hsu-Hage BH, Wahlqvist ML, Stroud DB. Agreement of skinfold measurement and bioelectrical impedance analysis (BIA) methods with dual energy X-ray absorptiometry (DEXA) in estimating total body fat in Anglo-Celtic Australians. Int J Obes. 1998;22:854-60.
22. Dehghan M, Merchant AT. Is bioelectrical impedance accurate for use in large epidemiological studies? Nutr J. 2008;7:26.

Cite this article as: Dube S, Viswanathan S, Dube M. Observational study of body weight, body fat with segmental fat distribution, visceral fat and body mass index in type 2 diabetic patients. Int J Res Med Sci 2016;4:4806-11.