Original Article

Correlation of Subcutaneous Fat Measured on Ultrasound with Body Mass Index

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Abstract

Background: Body mass index (BMI) is used for the assessment of obesity and overweight worldwide. When body fat is increased BMI is also increased. Ultrasound is a reliable method to assess body fat. We have selected only one suprapubic region for the assessment of fat which is very easy to measure even in routine pelvic and abdominal ultrasound examination. During our routine examination, we can measure abdominal fat and inform the patient about his/her health state regarding obesity. It was a hypothesis that increases in abdominal subcutaneous fat will increase in BMI. **Objective:** The objective is to correlate subcutaneous fats measured on ultrasound with BMI. **Materials and Methods:** It was a cross-sectional study, which was performed in Gilani ultrasound center, Lahore, Pakistan. A total of 384 participants were included with simple random sampling technique. Individuals of 16–60 years age of both genders were included in that study. Pregnant ladies, athletes, children, and elderly participants were not included in that study. Toshiba (Xario) and Mindray (Z5) ultrasound machine were used for subcutaneous fats measurement. Participants were scanned in the supine position. Subcutaneous fats were measured on the suprapubic region in three different trials. Compression was avoided. Compression artifacts were avoided by applying more quantity of gel between transducer and skin. Stadiometer was used for the measurement of weight and height. To calculate BMI, Quetelet index was used. BMI was calculated with that formula BMI = weight (kg) divided by height (m^2). **Results:** The result was made by calculation of mean and standard deviation. We calculated Pearson correlation between BMI and subcutaneous fats measured on ultrasound at the suprapubic region. It showed a significant high correlation between BMI and subcutaneous fat ($P = 0.0000$ which is < 0.001). **Conclusion:** There is a significantly high correlation between BMI and subcutaneous fat measured on ultrasound. Ultrasound is a reliable method to assess subcutaneous fat. It can be a predictor of obesity like BMI.

Keywords: Anthropometric measurements, body mass index, subcutaneous adipose tissues, ultrasonography

Introduction

Obesity is a global problem: Pakistan ranked in the ninth, among most obese country in the world. According to the World Health Organization, it estimates 26% of female and 19% of male in Pakistan are obese.[1] Six-hundred and seventy-one million people now fall into obese category worldwide. Obese people are more prone to health risks such as cardiovascular diseases, osteoarthritis, diabetes, hypertension, cancer, and kidney diseases.[2] Obesity is estimated to have caused 3.4 million deaths in 2010. The World Health Organization aims to stop the rise in obesity by 2025.[3] Obesity is an issue affecting people of all ages and incomes, everywhere.[4] Obesity is estimated by body mass index (BMI) worldwide. A person having BMI 30 kg/m^2 or more is considered obese and BMI 25 kg/m^2 or more is called overweight BMI stands for body mass index, in 1870 Quetelet, a Belgian astronomer and mathematician has set a formula for the assessment of BMI. In 1972, Quetelet Index termed as BMI by Ancel keys.[5]

According to this formula, BMI is expressed in kg/m^2. BMI = mass/height.[6] Just height and weight calculations are required for assessment, so it is easy to use and low-cost for general public and clinicians. BMI measures obesity, which is a very simple, inexpensive, and noninvasive method of measuring body fats, although it does not measure fats directly.[7]

Received: 06-12-2017 **Accepted:** 27-02-2018 **Available Online:** 14-12-2018

Access this article online	
Quick Response Code:	**Website:** www.jmuonline.org
	DOI: 10.4103/JMU.JMU_34_18

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How to cite this article: Nadeem B, Bacha R, Gilani SA. Correlation of subcutaneous fat measured on ultrasound with Body Mass Index. J Med Ultrasound 2018;26:205-9.

Fats stored in two different ways such as subcutaneous and visceral fats. Subcutaneous fats are stored beneath the skin and the visceral fats around the body organs. Everybody has subcutaneous fats but some people have more. Usually, women have more fat than men.[8] Body fats can be measured with different methods such as skin-fold calipers and underwater weighing, dual X-ray absorptiometry and bioelectric impedance, near infrared interactance, computed tomography (CT), magnetic resonance imaging (MR), and Ultrasonography.[9-11] Hydrostatic weighing is another method for estimation of body fats percentage. It does not measure visceral fat.[9] Bioelectric impendence analysis can also measure body fats percentage it works by passing a low-intensity electric current through the body.[12] Near-infrared interactance method can also assess body fats percentage. CT and MRI are also used for the measurement of body fat. Both methods are reliable but too expensive. Ultrasound has been used to estimate fats thickness since 1965. The speed of sound in soft tissue is 1540 m/s and speed of sound in fats is 1450 m/s due to this difference good interface is created and fats image is shown very well. To overcome the compression, artifacts thick layer of about 5 mm of gel against body and transducer should be used. Compression must be avoided to get accurate a result.[13]

Subcutaneous and visceral fats can be measured on ultrasound easily. Ultrasound could reliably and easily measure Subcutaneous fats during any examination procedure, that is, abdominal, gynecological, or superficial soft-tissue ultrasound.[14] Ultrasound is considered more accurate, reproducible, and sensitive modality as compared to other techniques, the reliability of ultrasound is recorded more than 98%.[15] No prior preparation is required for the measurement of subcutaneous fats measured on ultrasound. About 40% to 60% body fats accumulate subcutaneously.[16]

Materials and Methods

The correlation of subcutaneous fats measured on ultrasound with BMI was designed as a correlational analytical study with convenient non-probability sampling techniques. A sample size 0f 384 participants were taken. The study was carried out at Gilani ultrasound center and Afro-Asian Institute Lahore. Duration of the study was 6 months. Participants at the age of 16–60 years of both genders were included in this study. Pregnant ladies, athletes, children, and elderly individuals of both genders were excluded. High-frequency ultrasound machines Toshiba (Xario) and Mindray (Z5) with multi-Hertz linear frequency range from 7 to 14 MHz and convex transducers with frequency range 3–6 MHz a were used for the measurements of subcutaneous fat. Ultrasound machine Toshiba was used. The individuals were scanned under AIUM protocols, which are routinely observed in that department. Privacy of the individual was the first priority and informed consent was signed. The participants were scanned in the supine position and uncompressed subcutaneous fat was measured at the suprapubic region in three different trials. The mean of that three measurements was calculated to achieve accuracy [Figure 1]. Compression artifacts were avoided by applying an excessive amount of acoustic gel. All measurements were performed manually, parameters like measurements at three different trials were manually extracted, using electronic calipers, and stored directly in the database [Figure 2]. A medical stadiometer was used for the measurement of individual's weight and height to calculate BMI. BMI was calculated with the formula of BMI = weight (kg) ÷ height (m^2) by Quetelet index. Data collected from the examined participant was stored in a personal computer with a password, data collection sheets, and ultrasound images were protected in lockers. Personal identification of participants was kept secret. As this research follow scientific methods, related information's were taken from books, medical journals, articles data collecting sheets, and references were given in the chapter of references. Collected data were refined by making a statistical record using Statistical Package for the Social Sciences (SPSS) version 24 (IBM, Armonk, Ny, USA). The quantitative data presented in the form of mean and standard deviation. Pearson correlation was calculated. The values of regression coefficient (a and b), *R*-value with 95% confidence interval were calculated, and the results were presented in the form of scattered plot and regression formula.

Results

A total of 384 individuals of both genders were included in the study, in which 346 (90.1%) were females and 38 (9.9%) were males. The mean age was 32 ± 10.4 years ranging from 16 to 60 years. The mean weight was 58.9 ± 15.2 kg, ranging from 30 to 110 kg, while the mean height was 156 ± 13.8 cm ranging from 90 to 210 cm. The mean BMI was 24.09 ± 6.90 ranging from 12.10 to 61.5 kg/cm². Moreover, the mean abdominal subcutaneous fats were 18.45 ± 12.6 mm ranging from 4 to 86 mm [Table 1]. Correlation between BMI and subcutaneous fats was significant *P* value calculated less than

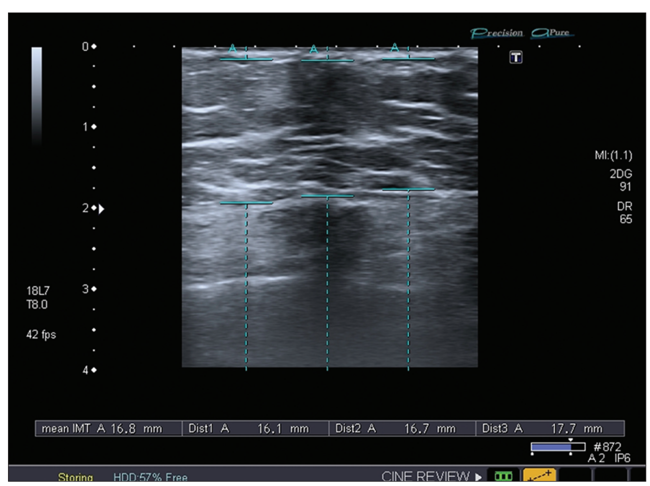

Figure 1: Subcutaneous fat measured on ultrasound in the suprapubic region with mean measurement 20.9 mm. The calculated body mass index was 25.5 kg/m^2

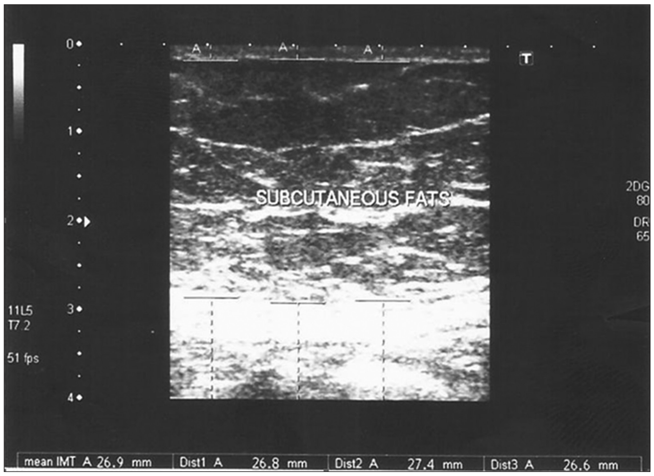

Figure 2: Measurement of subcutaneous fat measured on ultrasound with mean measurement of 26.9 mm, the calculated body mass index was 27.5 kg/m^2

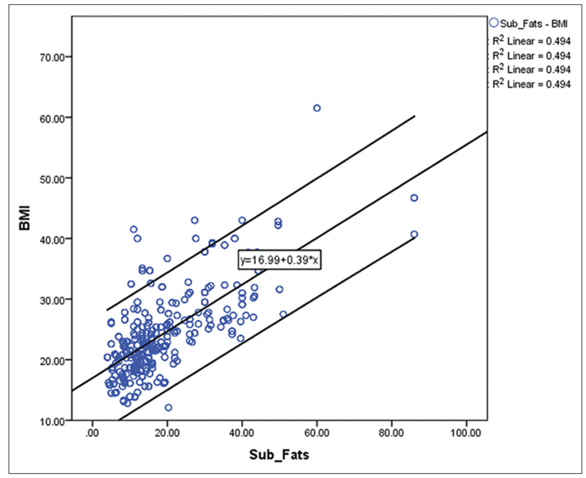

Figure 3: Scatterplot of body mass index and subcutaneous fats with 95% confidence interval, intercept (a) is 16.99 and slope of the curve (b) is 0.39

0.01 which meant for strong correlation. *R*-value is 0.703 which is near to 1, represents a strong positive relationship [Table 2 and Figure 3]. Regression between BMI and subcutaneous fats was calculated with 95% confidence interval, the values of coefficients intercept and slope (a, b) and standard deviations with upper and lower limits are shown in Table 3.

Formula

To calculate BMI from the measurement of subcutaneous fats the following formula is derived from a simple regression between BMI and subcutaneous fats.

$$Y = a + bx \quad (1)$$

here "y" represents BMI and "x" represents subcutaneous fats, whereas "a" intercept is 16.99 and "b" sloop is 0.39. While putting these values in equation 1, we got the following equation.

$$\text{BMI} = 16.99 + 0.39 \times \text{subcutaneous fats} \quad (2)$$

BMI could easily be calculated from the above equation by simply adding the valued of subcutaneous fats.

Table 1: Descriptive statistics of age, weight, height, body mass index, and subcutaneous fats

Variables	*n*	Minimum	Maximum	Mean±SD
Age	384	16.00	60.00	32.6979±10.44980
Weight	384	30.00	110.00	58.9427±15.24566
Height	384	90.00	210.00	156.8411±13.84447
BMI	384	12.10	61.50	24.0969±6.90710
Subcutaneous fats	384	4.00	86.00	18.4516±12.61209

SD: Standard deviation, BMI: Body mass index

Table 2: Correlations of body mass index and subcutaneous fats

	BMI	Subcutaneous fats
BMI		
Pearson correlation	1	0.703**
Significant (two-tailed)		0.0000
n	384	384

**Correlation is significant at the 0.01 level (two-tailed). BMI: Body mass index

Discussion

In the cross-sectional study of healthy individuals, measurements of subcutaneous fats measured on ultrasound and BMI measurements showed a strong correlation. Correlation of measurement of subcutaneous fats on ultrasound with BMI is important for easy estimation of obesity and overweight. Ultrasound measurement of subcutaneous fats predicts exactly total and segmental fats during abdomen and gynecological or superficial soft-tissue sonography. A-mode ultrasound along with other some anthropometric measurements such as thigh circumference and upper arm circumference is an accurate method for the assessment of body fats percentage. Skinfold calipers thickness measurement were compared to ultrasound measurements. Skinfold calipers were used at three sites in both genders significant correlation was found ($P < 0.001$) $r = 0.92$ compared to ultrasound.[17] Most strong correlation between BMI and waist circumference is proven. In women, BMI and waist circumference are significantly correlated ($P < 0.001$) in men, BMI, and waist circumference also strongly correlated as (<0.05). Increased waist circumference can also increase health risk. Usually, increased waist circumference is due to increase abdominal subcutaneous fat.[18] In a previous research, a comparison of BMI, waist circumference, and waist-to-height ratio as a predictor of abdominal fat distribution is proven.[18] A positive correlation between the measurements of CT, MRI, and measurements of ultrasonography of body fat was shown in a previous research paper. In that research, it was said that ultrasound is a reliable method to estimate body fat when CT and MRI are not feasible.[19] It is essential to assess body fats not only to minimize health problem but also for the sake of body

Table 3: Regression table shows the "a" and "b" values with standard error and level of significance with 95% confidence interval

Model	Unstandardized coefficients		Standardized coefficients	*t*	Significant	95.0% CI for B	
	B	SE	β			Lower bound	Upper bound
Model 1							
(Constant)	16.991	0.445		38.174	0.0000	16.116	17.866
Subcutaneous fats	0.385	0.020	0.703	19.329	0.0000	0.346	0.424

[a]Dependent variable: BMI. BMI: Body mass index, CI: Confidence interval, SE: Standard error

shape. It is believed that the result of that research, while using ultrasound for the estimation of BMI may potentially help to bring the technology into the general application by making it more user-friendly. The rationale of the study was to evaluate the role of ultrasound in measurement subcutaneous fats in our population as shown in previous studies. It is said in a previous study that ultrasound is a reliable and easier method of measuring abdominal fat and the actual measurement of abdominal fat by ultrasound are more informative than other anthropometric measurements.[20] Our study was carried out to see whether the results in our population matches with previous studies or not.

Previous studies reported that ultrasound measurements by A-mode and B-mode ultrasound were correlated with real measurements of subcutaneous tissues in cadaver's study. Some previous studies show a significant correlation of skinfolds calipers and ultrasound measurements of subcutaneous adipose tissues. All previous studies examined the relationship of body fats percentage with other anthropometric measurements such as waist circumference, biceps, and triceps circumference with BMI to assess body fats percentage. Only one study was reported a relation of subcutaneous adipose tissues measurements with BMI; however, they have selected eight sites for measurement. None of the previous studies correlated BMI with subcutaneous fats measured at suprapubic region. It shows that if subcutaneous fat at suprapubic region increases, BMI will also increase [Figures 1 and 4]. The strength of our study is that to the best of our knowledge; it represents the first study to prove a correlation between subcutaneous adipose tissues measured on ultrasound at the suprapubic region with BMI. It has shown a significant correlation between BMI and subcutaneous adipose tissues measurements on ultrasound.

Figure 4: Subcutaneous fats measured with convex transducer during routine abdominal sonography mean thickness 29.0 mm. The BMI of the individual calculated as 28.3 kg/m^2

Conclusion

There is a strong correlation between subcutaneous fats measured on ultrasound at suprapubic region and BMI. Ultrasound can also predict the obesity and overweight like BMI. Ultrasound is not going to replace the BMI calculated by conventional standard methods, but rather it is easy during the abdominal or gynecological examination to measure the subcutaneous fats and ultimately calculate the BMI to inform the patient about their obesity.

Recommendations

This study found a very significant, good correlation between BMI and subcutaneous fats in suprapubic region, and regression formula is made statistically, but further studies should be conducted on a very large sample, for verification. The estimation of BMI from the sonographic measurement of subcutaneous fats during the abdominal, gynaecology, or obstetrical ultrasound examination is good. The occasional use of ultrasound for measuring subcutaneous fats, but BMI calculation, from body weight and height should not be replaced. Ultrasound is not recommended to be performed solely for the calculation BMI. In case of abnormal results, it must be confirmed by the conventional method of BMI calculation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Shabana, Hasnain S. The fatty acid binding protein 2 (FABP2) polymorphism ala54Thr and obesity in Pakistan: A population based study and a systematic meta-analysis. Gene 2015;574:106-11.
2. Nazare JA, Smith J, Borel AL, Aschner P, Barter P, Van Gaal L, *et al.* Usefulness of measuring both body mass index and waist circumference for the estimation of visceral adiposity and related cardiometabolic risk profile (from the INSPIRE ME IAA study). Am J Cardiol 2015;115:307-15.
3. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, *et al.* Global, regional, and national prevalence of overweight and

obesity in children and adults during 1980-2013: A systematic analysis for the global burden of disease study 2013. Lancet 2014;384:766-81.
4. Lim SS, Fullman N, Murray CJ, Mason-Jones AJ. Measuring the health-related sustainable development goals in 188 countries: A baseline analysis from the global burden of disease study 2015. Lancet 2016;388:1-38.
5. Yadav S. The assessment of obesity: Methods for measuring body fat and global prevalence of obesity. Deliberative Res 2016;31:63.
6. Van Dyck D, Cerin E, De Bourdeaudhuij I, Hinckson E, Reis RS, Davey R, *et al.* International study of objectively measured physical activity and sedentary time with body mass index and obesity: IPEN adult study. Int J Obes (Lond) 2015;39:199-207.
7. Liu P, Xu L, Wang Y, Zhang Y, Du Y, Sun Y, *et al.* Association between perinatal outcomes and maternal pre-pregnancy body mass index. Obes Rev 2016;17:1091-102.
8. Zhu K, Hunter M, James A, Lim EM, Cooke BR, Walsh JP, *et al.* Discordance between fat mass index and body mass index is associated with reduced bone mineral density in women but not in men: The busselton healthy ageing study. Osteoporos Int 2017;28:259-68.
9. Gibby JT, Njeru DK, Cvetko ST, Heiny EL, Creer AR, Gibby WA, *et al.* Whole-body computed tomography-based body mass and body fat quantification: A Comparison to hydrostatic weighing and air displacement plethysmography. J Comput Assist Tomogr 2017;41:302-8.
10. Miller RM, Chambers TL, Burns SP, Godard M. Validating inbody® 570 multi-frequency bioelectrical impedance analyzer versus DXA for body fat percentage analysis. Med Sci Sports Exerc 2016;48 5 Suppl 1:991.
11. Surendar J, Indulekha K, Deepa M, Mohan V, Pradeepa R. Association of adiposity, measured by skinfold thickness, with parental history of diabetes in a South Indian population: Data from CURES-114. Postgrad Med J 2016;92:379-85.
12. Nickerson BS, Esco MR, Kliszczewicz BM, Freeborn TJ. Comparison of bioimpedance and underwater weighing body fat percentage before and acutely after exercise at varying intensities. J Strength Cond Res 2017;31:1395-402.
13. O'Neill DC, Cronin O, O'Neill SB, Woods T, Keohane DM, Molloy MG, *et al.* Application of a sub-set of skinfold sites for ultrasound measurement of subcutaneous adiposity and percentage body fat estimation in athletes. Int J Sports Med 2016;37:359-63.
14. Störchle P, Müller W, Sengeis M, Ahammer H, Fürhapter-Rieger A, Bachl N, *et al.* Standardized ultrasound measurement of subcutaneous fat patterning: High reliability and accuracy in groups ranging from lean to obese. Ultrasound Med Biol 2017;43:427-38.
15. Smith-Ryan AE, Fultz SN, Melvin MN, Wingfield HL, Woessner MN. Reproducibility and validity of A-mode ultrasound for body composition measurement and classification in overweight and obese men and women. PLoS One 2014;9:e91750.
16. Carpéné C, Les F, Hasnaoui M, Biron S, Marceau P, Richard D, *et al.* Anatomical distribution of primary amine oxidase activity in four adipose depots and plasma of severely obese women with or without a dysmetabolic profile. J Physiol Biochem 2016;73:475-86.
17. Hyde PN, Kendall KL, Fairman CM, Coker NA, Yarbrough ME, Rossi SJ, *et al.* Use of B-mode ultrasound as a body fat estimate in collegiate football players. J Strength Cond Res 2016;30:3525-30.
18. Kim DW, Kim JY, Jeong H. Comparison of body mass index, waist circumference, and waist-to-height ratio as a predictors of abdominal fat distribution in male examinees from the health promotion center. Korean J Fam Pract 2017;7:596-9.
19. De Lucia Rolfe E, Sleigh A, Finucane FM, Brage S, Stolk RP, Cooper C, *et al.* Ultrasound measurements of visceral and subcutaneous abdominal thickness to predict abdominal adiposity among older men and women. Obesity (Silver Spring) 2010;18:625-31.
20. Premanath M, Basavanagowdappa H, Mahesh M, Babu MS. Occurrence of diabetes mellitus in obese nondiabetic patients, with correlative analysis of visceral fat, fasting insulin, and insulin resistance: A 3-year follow-up study (Mysore visceral adiposity in diabetes follow-up study). Indian J Endocrinol Metab 2017;21:308-15.