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# Ultrasonography Measurement of Abdominal Subcutaneous Fat Thickness and Its Correlation with Hyperlipidemia and Steatohepatitis in Obese People

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## Introduction

Unhealthy dietary practices, sedentary lifestyle and obesity have emerged as major risk factors of Non communicable diseases (NCD).[1] In India there is shift in dietary patterns to more 'Western' diets rich in saturated fat, refined foods and sugar and low in fibre[2] due to which there is a higher prevalence of traditional cardiovascular disease risk factors such as obesity, physical inactivity, tobacco use and high intake of saturated fat.[3] In 2000, the International Obesity Task Force of the WHO (IOTF-WHO) proposed a modification of National Heart, Lung, and Blood Institute guidelines on overweight/obesity which is as follows : Overweight, 23 to <25; class I obesity, 25 to <30; and class II obesity, ≥30. Redefining the obesity cut-off (BMI >25) creates an "obesity burden" in urban India.[4]

World Health Organization in 2011, reported that the prevalence of obesity has doubled in the last 3 decades.[5] The prevalence of obesity in India is continuously increasing and data shows that around 13% to 50% of the urban population and 8%-38.2% of the rural population is suffering from obesity. Obesity is common in women as compared to men.[6] Also there is increase in the childhood obesity which can cause many complications such as hyperlipidemia and steatohepatitis at an early age. It may also lead to obesity in adulthood and thereby result in many lifestyle diseases.[7] Some studies have reported that 28.3% and 16.7% of obese children have above normal levels of serum triglycerides and total cholesterol respectively but fatty liver, as a result of obesity, can progress to liver cirrhosis.[8,9] The most common cause of chronic liver disease in adults and children is non-alcoholic fatty liver disease (NAFLD). In adults the prevalence of NAFLD ranges from 17% to 33%,[1] whereas in children, it ranges from 2.6% to 9.6%, and from 22.5% to 44% in children with obesity.[10,11] The presentation of NAFLD may vary from simple liver steatosis to non-alcoholic steatohepatitis (NASH), liver cirrhosis and may be hepatocellular carcinoma.[12] The pathogenesis of NAFLD is still a problem with a plethora of implications and potential solutions for clinical practice. Many people are affected by NAFLD and around 60%-70% remain asymptomatic with simple liver steatosis.[13]

To measure fat thickness ultrasound was used from mid 1960s.[14] Measurement of the thickness of subcutaneous and visceral fat have been studied by computed tomography, dual-energy X-ray absorptiometry, and abdominal ultrasonography.[15,16,17] Ultrasonography seems to be used far less than the other methods for body composition assessment, many students and clinicians are not familiar with its usefulness and versatility as a body composition assessment tool.

The aim of this study is to measure the subcutaneous fat in obese persons and review of ultrasound technology is to explain the technical principles of the method and measurement procedures

## Material and Methods

This prospective study was carried out at Nepal Medical College and Teaching Hospital Jorpati, Kathmandu in Department of Radiology. Total of 200 patients were included in the study. The BMI of the entire subject was calculated using their weight and height. BMI above the 95th percentile was defined as obese. Serum lipid profile and liver amino transferase levels were measured of all the participants included in the study.

Technical principle of ultrasonography- Sound travels in the form of a cyclical wave and human body can detect sound with a frequency of about 20 to 20,000 Hz. Pulses of ultrasound are produced by Piezoelectric crystals in the transducer of the scan head. Beam of ultrasound is transmitted through the skin. When the ultrasound beam comes in contact with any tissue interface i.e. skin-subcutaneous fat, fat muscle and muscle bone, it is partially reflected back to the transducer as an echo. The transducer has a dual function of transmitting the ultrasound and receiving it. The echoes are converted into signals for processing by the transducer. The strength of each reflected wave is represented by a dot and the position of the dot represents the depth from which the echo was received. The dots are combined to form an image. Thus the principle of ultrasound imaging is reflection of ultrasound waves from tissue in the path of the beam. The amount of sound reflected is dependent on the changes in acoustic impedance between two tissue interfaces. Fat and muscle have impedances of $0.138\ g\cdot cm^{-1}\cdot s^{-1}$ and $0.170\ g\cdot cm^{-1}\cdot s^{-1}$, respectively while bone has a relatively high impedance of $0.78\ g\cdot cm^{-1}$. 1010

***Procedure of ultrasound-*** Gel is placed on the head of the transducer and/or the skin at the site to be measured. Abdominal subcutaneous fat thickness was measured in the supine position during normal respiration with minimal pressure applied by the US probe. Midline abdominal subcutaneous fat thickness (MASFT) was measured transversely at about one cm caudal to the umbilicus level and the right flank abdominal subcutaneous fat thickness (RFASFT) was measured coronally at two locations of the right flank with the average value being recorded.

To diagnosis the Hepatic steatosis ultrasonography was done. A 6.0 MHz probe was used to look for the echogenicity of the liver in the diagnosis of hepatic steatosis. Suspected steatosis was graded as

**Grade I (mild):** slight diffuse increase in the fine echoes in the hepatic parenchyma with normal visualization of the diaphragm and intra hepatic vessel borders.

**Grade II (moderate):** moderate diffuse increase in the fine echoes with slightly impaired visualization of the intra hepatic vessels and diaphragm.

**Grade III (severe):** marked increase in fine echoes with poor or non visualization of the intra hepatic vessel borders, diaphragm, and posterior portion of the right lobe of the liver.

## Results and Observations

A total of 200 people were included in the study of which 90 were male and 110 were female. Average age of participants was 38±16.8 (mean ± standard deviation). Mean age of male was 35±21.4 and that of females was 39±15.7. Mean weight was 61±14.4. Mean weight of males was 64±11.4 and females was 56±12.6. Mean height in cm was 154±5.2. Mean height of males was 159±9.6 and females was 142±6.4. Mean BMI of total patient was 27±4.3. Mean BMI of males was 27±3.4 and females was 28±4.6. As compared to males BMI of females was higher.

**Table 1: Age, Sex, Weight, Height and BMI of participants**

| | N=200 | MALE | FEMALE | Standard error | 95% CI | t-statistic | Significance level |
|---|---|---|---|---|---|---|---|
| **Age** | 38±16.8 | 35±21.4 | 39±15.7 | 1.877 | 0.3104 to 7.6896 | 2.131 | P = 0.0337 |
| **Sex** | 110 F/ 90 M | 90 | 110 | | | | |
| **Weight (kg)** | 61±14.4 | 64±11.4 | 56±12.6 | 1.201 | -10.3621 to -5.6379 | -6.658 | P < 0.0001 |
| **Height (cm)** | 154±5.2 | 159±9.6 | 142±6.4 | 0.816 | -18.6039 to -15.3961 | -20.837 | P < 0.0001 |
| **BMI** | 27±4.3 | 27±3.4 | 28±4.6 | 0.404 | 0.2048 to 1.7952 | 2.472 | P = 0.0138 |

*Values are presented as mean±standard deviation.*

**Table 2: Serum cholesterol and Liver profile**

| S size | 200 | Male | Female | Standard error | 95% CI | t-statistic | Significance level |
|---|---|---|---|---|---|---|---|
| **Tot Cholesterol** | 187±24.7 | 189±22.5 | 176±19.4 | 2.101 | -17.1299 to -8.8701 | -6.188 | P < 0.0001 |
| **TG** | 141.5±88.8 | 159±56.7 | 139±77.4 | 6.784 | -33.3378 to -6.6622 | -2.948 | P = 0.0034 |
| **HDL** | 48.4±11.4 | 49±10.5 | 46±9.8 | 1.016 | -4.9966 to -1.0034 | -2.954 | P = 0.0033 |
| **LDL** | 101.0±32.7 | 102±29.4 | 96±22.5 | 2.618 | -11.1465 to -0.8535 | -2.292 | P = 0.0224 |
| **AST** | 41.7±29.7 | 43±29.8 | 40.5±27.4 | 2.863 | -8.1275 to 3.1275 | -0.873 | P = 0.3830 |
| **ALT** | 58.4±61.4 | 59.7±67.5 | 55.4±52.1 | 6.029 | -16.1534 to 7.5534 | -0.713 | P = 0.4762 |

TG: triglyceride, HDL: high density lipoprotein, LDL: low density lipoprotein, AST: aspartate aminotransferase, ALT: alanine aminotransferase.

Total serum cholesterol, triglyceride, high density lipoprotein and low density lipoprotein was 187±24.7, 141.5±88.8, 48.4±11.4, 101.0±32.7 respectively while AST and ALT was 41.7±29.7, 58.4±61.4 respectively.

**Table 3: Hepatic steatosis and grading**

| hepatic steatosis | Total n=200 | Male n=90 | Female n=110 | 95% CI | Chi-squared | Significance level |
|---|---|---|---|---|---|---|
| **Normal** | 73 (36.5%) | 32 (43.84%) | 41 (56.16%) | -3.8112 to 27.5802 | 2.201 | P = 0.1379 |
| **Grade I** | 54 (27%) | 21 (38.89%) | 33 (61.11%) | 3.3787 to 38.9743 | 5.283 | P = 0.0215 |
| **Grade II** | 66 (33%) | 37 (56.06%) | 29 (43.94%) | -4.8194 to 28.1166 | 1.924 | P = 0.1654 |
| **Grade III** | 7 (3.5%) | 4 (57.14%) | 3 (42.86%) | -31.1108 to 52.5151 | 0.265 | P = 0.6066 |

Of the total 200 patients 54 (27%) were observed with grade I hepatic steatosis, while 66 (33%) and 7 (3.5%) were grade II and grade III respectively.

 

**Table 4: Midline Abdominal Subcutaneous Fat Thickness, Right Flank Abdominal Subcutaneous Fat Thickness and Grade of Hepatic Steatosis**

| Grade of hepatic steatosis | MASFT in cm | RFASFT in cm |
|---|---|---|
| **Normal n=73** | 2.1±0.6 | 1.6±0.4 |
| **Grade I** | 3.2±0.5 | 2.1±0.5 |
| **Grade II** | 3.6±0.6 | 2.5±0.7 |
| **Grade III** | 4.3±0.7 | 3.0±0.8 |

***MASFT:*** midline abdominal subcutaneous fat thickness, RFASFT: right flank abdominal subcutaneous fat thickness.

Midline Abdominal Subcutaneous Fat Thickness (MASFT) in normal was 2.1±0.6, while in Grade I, Grade II and in Grade III was 3.2±0.5, 3.6±0.6 and 4.3±0.7 respectively. Right flank abdominal subcutaneous fat thickness (RFASFT) in normal, Grade I, Grade II and in Grade III was 1.6±0.4, 2.1±0.5, 2.5±0.7 and 3.0±0.8 respectively. Statistically significant correlation was observed between MASFT and the grade of hepatic steatosis ($p=0.000$). RFASFT also had a statistically significant correlation with the grade of hepatic steatosis ($p<0.001$).

## Discussion

During this early period of late 1960s through mid-1980s, there were different opinions as to which method, ultrasound or skinfold, best measured subcutaneous fat. Sloan in his studies in 1967 compared seven skinfold site to ultrasound measures taken at the same locations and to densitometry from underwater weighing.[18] Fanelli and Kuczmarski was suggested that ultrasound was equal to skinfolds for predicting body fat.[19] Leahy et al.[20] in 2012 observed that a single ultrasound measure of subcutaneous adipose tissue at the abdomen was highly correlated with body fat percentage.

Recent studies suggest that ultrasound is a reliable, and fast method for assessing both subcutaneous and visceral adipose compartments. Bazzocchi et al.[21] shown the relationships between computed tomography (CT) and ultrasound measures of visceral and subcutaneous parameters. There are many advantages to determine the subcutaneous fat by ultrasound but there are some disadvantages like fascia could be mistaken for the boundary layer between subcutaneous fat and muscle or pressing the transducer onto the patients skin with greater force will significantly reduce the subcutaneous fat thickness.[22]

To detect Steatosis ultrasonography can be a accurate tool to diagnose the condition in early stages when serum AST, ALT levels are normal. In our study MASFT > 4.0 suggest the severe hepatic steatosis while <2 was seen in normal individuals. Also RFASFT > 3.0 suggest the severe hepatic steatosis while <1.6 was seen in normal individuals. Eifler[23] in his study shown that For women, visceral fat thickness ≥ 7 cm suggests the presence of mild steatosis; and ≥ 9 cm suggests moderate to severe steatosis with risk for steatohepatitis and metabolic syndrome. For men, visceral fat thickness ≥ 8 cm suggests the presence of mild steatosis; and ≥ 10 cm, suggests moderate to severe steatosis with risk for steatohepatitis and metabolic syndrome. While Leite et al., investigated the correlation between visceral fat thickness and cardiovascular risk. His study has indicated a cut-off value of 7 cm to predict a moderate cardiovascular risk for both female and male individuals.[24] In our study no statistically significant difference was observed in subcutaneous fat thickness between male and female individuals, age groups and in relation to the presence or not of steatosis but statistical significant difference was observed in serum cholesterol levels of men and women.

## Conclusion

Our study demonstrated the correlation between steatosis and subcutaneous fat thickness measured by ultrasonography and values were suggested for normality and risk for hepatic steatosis for both male and female individuals. So it is suggested that subcutaneous fat measurement should be included in the routine abdominal ultrasonography studies as a predictor of hepatic steatosis and metabolic syndrome

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