Public health semantics of YY paradox

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Abstract

Background: Body Mass Index (BMI) has lost its credibility as an indicator of fatness. 3D scan and body composition details of Yajnik and Yudnik, the authors with similar BMI but very different body fat percentage was labelled as 'YY paradox'. 3D scanners are not widely available; as such dependence on less specific tools is still high. It was assumed that such paradoxes may frequently occur in anthropometrically derived body composition indices and paucity of such information prompted us to explore the nature and usage of YY paradox.

Methods: Body composition of 89 medical students from North India was studied using bioelectric-impedance fat monitor and anthropometric techniques. YY phenomenon were identified and studied in 1) same BMI but different body fat (Classic YY), 2) same BVI but different BMI (yy BVI~BMI), 3) same Skeletal mass/body fat but different body volume (yy SKM/BF ~ BV) and 4) same Lean Body mass/body fat but different body volume (yy LBM/BF ~ BV).

Results: The study population comprised young adults aged 18 -26 years. Males comprised 51.7 % of the study group. YY phenomenon was found in 44 individuals with respect to same BMI but different body fat; 47 individuals of same BVI but different BMI. Of all the indices studied, lowest number of YYs were found in yy LBM/BF ~ BV index. 14.6% study subjects had high visceral fat. Odds Ratio (OR) for high visceral fat in all the studied indices among subjects showing yy-phenomenon and those not showing yy-phenomenon revealed an OR of 1.09 (CI 0.3-3.7) for yy LBM/BF ~ BV index. This suggests that high visceral fat (VF) is the same in both groups and implies that there is no difference between the two arms i.e., YY and non-YY group contains approximately similar proportion of subjects with high VF.

Conclusion: We found a high frequency of such paradoxes in this population and also demonstrated that these are not normally distributed. It is also suggested that a deeper look in this issue could be used for deriving predictive models for disease linked anthropometric markers.

Introduction

The analysis of health and nutrition data from various countries shows many surprising and seemingly incomprehensible facts and paradoxical relationships (Ginter, 2009). The hundred and seventy years old body mass index (BMI) for assessing fatness was discredited by YY paradox; Yajnik and Yudnik the authors had similar body mass index (BMI) but grossly different body fat percentage. This gained fame as YY paradox (Yajnik, Yudkin, 2004). Emerging technology of 3D scan for measuring body fat paved the way for a new index called body volume index (BVI) (Larsson B et al, 1984). Bihari et al recently demonstrated an association between mathematically derived BVI and musculoskeletal pain among house wives of Delhi (Bihari et al., 2013)

The YY paradox or the phenomenon of two or more people sharing a similar value in anthropometrically derived indices but having different body composition has been referred as yy-phenomenon in this paper. The yy-phenomenon has hardly been studied.

In any population study of body composition parameters, two or more people of same or different sex with varying body compositions will share some of the values of the parameters under study. This is a confounder but it provides an opportunity to establish the YY paradox as a predictor for disease linked easily measurable index. As such a study of such phenomenon may yield substantial benefits to public health.

Half a century ago, Jean Vague, a French physician observed that subjects with thicker waists were at higher risk of early cardiovascular disease and fatality as compared to subjects with thinner waists (Vague J, 1947). Long-term follow-up studies demonstrated that ‘abdominal obesity’ was significantly associated with higher risk of type 2 diabetes, heart disease and mortality, though BMI values were statistically controlled (Ohlson LO, Larsson B, Svardsudd K, et al., 1985). The present study attempts to explore the frequency and uses of yy-phenomenon in some commonly used body composition indices vis a vis abdominal obesity.

Material and Methods

A cross-sectional study was conducted among students of a medical school of North India. All the first year students who consented to participate (89 of the 90) were studied during the month of May-June 2015.

A general clinical examination of each subject was done to confirm that the studied subjects were not suffering from any acute or chronic diseases.

Body composition was analysed using bioelectric impedance (Model: OMRON Hbf 375). The variables included -weight, BMI, body fat percentage (BF%) and visceral fat percentage (VF%). VF was classified as normal (≤9.5), high (10-14.5) and very high (15.0-30.0) (Swaroopa Rani N, 2014).

Height, weight and waist circumference were measured as per standard methods (NHANES, 2007).

The following indices were derived as described below.

- BSA (Body Surface Area) was calculated using formula BSA = 0.007184 x Weight (kg)$^{0.425}$ x Height (cm)$^{0.725}$ (DuBois D, DuBois EF,1916)
- Body Volume Index -BVI (V/S) was calculated using formula BVI = S (51.44 W/H + 15.3) (Sendroy JJ, Collison HA, 1966) where W= weight in kg, H=height in cm, S= body surface area in m^2
- Body Volume (BV) was calculated as product of BVI and BSA
- Lean Body Weight (men) = (1.10 x Weight(kg)) - 128 x (Weight^2/(100 x Height(m))^2) (Hallynck TH, Soep HH et al, 1981)
- Lean Body Weight (women) = (1.07 x Weight (kg)) - 148 x (Weight^2/(100 x Height(m))^2) (Hallynck TH, Soep HH et al, 1981).

All the yy-phenomenon for following body composition indices were identified in the study population.

1. Same BMI but different body fat (Classic YY)
2. Same BVI but different BMI (yy BVI~BMI)
3. Same Skeletal mass/Body fat but different body volume (yy SKM/BF ~ BV)
4. Same Lean Body Mass/Body fat but different body volume (yy LBM/BF ~ BV)

All information was compiled using MS Excel. Analysis was done with MS Excel and Statistical Package for Social Sciences (SPSS) software. Appropriate statistical tests were be applied as required.

Ethical clearance from Institutional Human Ethical Committee of Hind Institute of Medical Sciences (Letter No. HIMS/IHPC/013/2014) was obtained before starting the study.

Informed consent was taken in writing from each of the study participant after explaining the purpose of the study in local language using a study information brochure.

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Results

The study population comprised of young adults aged 18 -26 years. Males comprised 51.7 % of the group. Age and gender profile of the study subjects is depicted in Fig. 1. All the participants had a family income of more than Rs 60,000 per capita as compared to per capita income of Rs. 33,137 in Uttar Pradesh (Maps of India, 2013).

The mean with standard deviation and median and range for studied body composition parameters and indices of the study subjects is shown in Table 1. All the variables were found to be lognormally distributed. This was as in consonance with findings of Penman and Johnson. (Penman and Johnson, 2006).

yy BMI ~ BF was found in 44 individuals, yy (1male and one female) were 17, yy among males was 16; and 11among females. Similarly, 47 individuals had yy-phenomenon of same BVI but different BMI. yy (1male and one female) were 13. yy among males was 21; and 13 among females. Of all the indices studied, lowest number of yy-phenomenon was found in index yy LBM/BF ~ BV. The details are shown in Table 2. The distribution of the yy-phenomenon for the four studied body indices was found to be skewed. The histogram are shown in Fig. 2.

Waist circumference (WC) is widely used as an indirect measure of abdominal adiposity in epidemiological studies (Zhang et al., 2008). 14.6% study subjects had high/very high visceral fat. Figure 3 depicts a good association of visceral fat with waist circumference in this population.

Odds Ratio (OR) were calculated for high visceral fat in all the studied indices among subjects showing yy-phenomenon and those not showing yy-phenomenon. Highest OR of 1.09 (CI 0.3-3.7) was found only for yy LBM/BF ~ BV as shown in Table 3. This shows that high/very high visceral fat is the same in both groups, which implies that there is no difference between the two arms of the study group (yy and Non yy groups).

Discussion

YY paradox was a novel way of highlighting the fact that people with same BMI may have very different body structures. It has been used by 3D scan manufacturers for highlighting the difference in fat percentages among people with same BMI. Taking a lead from it we studied the same for four different body indices.

Hollywood celebrities Dita Von Teese and Jessica Biel have a BMI of 16.6 (Stylite, 2015). A step forward -people having the same height, weight and consequently the same BMI may have

very different body compositions. Many such graphs are available on the internet (POSH24*,2009). Gomez-Ambrosi et al, assessed the BMI, body fat percentage, and cardio-metabolic risk factors of 6123 (924 lean, 1637 overweight and 3562 obese classified according to BMI) Caucasian subjects (69% females) between the ages of 18 and 80 years (Gomez A et al, 2012). They found that 29% of subjects classified as having normal weight and 80% of individuals classified as overweight according to BMI had a body fat percentage within the obese range. Thus, on an individual basis BMI tends to consistently underestimate a person's adiposity.

The distribution and frequency of yy-phenomenon in young affluent adults for parameters like BMI, body fat, visceral fat, body volume index, skeletal mass and lean body mass have been described here. We demonstrated that these are not normally distributed. Furthermore, all the studied indices showed a prevalence of yy-phenomenon ranging from 29.6 – 52.8%. The lowest prevalence of 29.6% yy- phenomenon was observed in index of yy LBM/BF ~ BV. As yy-phenomenon leads to confusion about actual body type, any indicator which has the least number of yy values is obviously more accurate than those with higher frequency of yy.

The results show that the yy phenomenon in yy LBM/BF ~ BV has the best odds of identifying the proportion of subjects with high visceral fat in this population. It is hypothesised that subjects of this age group and economic status in this city would have approximate prevalence of abdominal obesity that is roughly equal to the prevalence of yy-phenomenon in yy LBM/BF ~ BV. This hypotheses needs to be substantiated by more detailed studies.

Accumulating evidence indicates that abdominal adiposity is positively related to cardiovascular disease (CVD) risk (Zhang et al., 2008). This approach could be fruitfully used for detection of the magnitude of abdominal obesity, in well-defined sub-populations even in small sample of population.

The study limitations include – small sample size, restricted to young adults. Secondly the results could not be examined in a wider horizon as the issue has not been well explored.

Conclusion

This small exploratory study has found that YY paradox is frequently encountered in anthropometric data and body composition indices. This type of data does not follow the normal Gaussian distribution. Further, it shows that study of yy-phenomenon may yield important information that could help assess magnitude of anthropometric trends linked to current disease epidemics.

References

1. Bihari V, Kesavachandran CN, Mathur N, Pangtey BS, Kamal R, Pathak MK, Srivastava AK. 2013. Mathematically derived body volume and risk of musculoskeletal pain among housewives in North India. *PLOS ONE*, 8(11): 1-11.
2. DuBois D, DuBois EF. 1916. A formula to estimate the approximate surface area if height and weight be known. *Arch Intern Med*, 17: 863-871.
3. Ginter E1, Simko V, Dolinska S. 2009. Paradoxes in medicine: an access to new knowledge? *Bratisl Lek Listy*, 110(2):112-5.
4. Gómez A, Silva C, Galofré JC, Escalada J, Santos S, Millán D, Vila N, Ibañez P, Gil MJ, Valentí V, Rotellar F, Ramírez B, Salvador J, Frühbeck G. 2012. Body mass index classification misses subjects with increased cardiometabolic risk factors related to elevated adiposity. *International Journal of Obesity*, 36: 286–294.
5. Hallynck TH Soep HH, Thomis J A, Boelaert J, Daneels R, Dettli L. 1981. Should clearance be normalised to body surface or to lean body mass? *Br J Clin Pharmacol*, 11: 523-526.
6. Larsson B, Svardsudd K, Welin L, Wilhelmsen L, Bjorntorp P, Tibblin G. 1984. Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. *Br Med J (Clin Res Ed)*, 288:1401-4.
7. Maps of India. Available on: http://www.mapsofindia.com/maps/india/percapitaincome.htm. (Accessed on: 15th October 2015).
8. National Health and Nutrition Examination Survey (NHANES). 2007. Available from: http://www.cdc.gov/nchs/nhanes.htm (Accessed on: 20th March 2015).
9. Ohlson LO, Larsson B, Svardsudd K, Welin L, Eriksson H, Wilhelmsen L, Björntorp P, Tibblin G. 1985. The influence of body fat distribution on the incidence of diabetes mellitus. 13.5 years of follow-up of the participants in the study of men born in 1913. *Diabetes*, 34:1055-8.
10. POSH 24*. 2009. 6 Women, Same BMI, Different Bodies: Chart Proves Numbers Can't Always Measure Health. by Hannah Ongley. 2015. Available from: http://www.styleite.com/news/handy-womens-body-shape-chart-proves-your-bmi-is-not-an-accurate-measure-of-your-health/ (Accessed on: 15th October 2015).

11. Sendroy JJ, Collison HA. 1966. Determination of human body volume form height and weight. J Appl Physiol, 21: 167-172. PubMed: 5903906
12. Stylite. 2015. The Facts: How Much Hollywood Hotties Really Weigh! Avilable from: http://www.posh24.com/megan_fox/the_facts_how_much_hollywood_hotties_really_weigh. (Accessed on: 15th October 2015).
13. Swaroopa Rani N. Gupta. 2014. Body Composition Analysis of Staff members of College Using Bioelectrical Impedance Analysis Method. *International Journal of Chemical Engineering and Applications*, 5(3): 259-265. DOI: 10.7763/IJCEA.2014.V5.390.
14. Vague, J. 1947. La differenciation sexuelle facteur determinant des formes de l'obésité. *Presse Medicale*. 55: 339–40.
15. Yajnik CS, Yudkin JS. 2004. The Y-Y paradox. *The Lancet*, 363: 163.
16. Zhang C, Rexrode KM, Dam RM., Tricia Y Li, Frank BH. 2008. Abdominal Obesity and the Risk of All-Cause, Cardiovascular, and Cancer Mortality Sixteen Years of Follow-Up in US Women. *Circulation*, 117: 1658-1667.

Table 1: Distribution of body composition variables in study population

Body Composition Indices	MEDIAN (RANGE) N=89	MEAN ±S.D N=89
BMI	23.90 (15.30 - 41.70)	23.9 ± 4.85
BV (in litres)	59.60 (37.51 - 128.45)	60.66 ± 14.22
BVI	35.09 (28.23 - 53.13)	35.60 ± 4.38
SKELETAL MASS %	29.20 (21.00 - 39.50)	29.53 ± 4.85
LEAN BODY MASS %	47.00 (21.8 - 73.6)	47.70 ± 9.44
VISCERAL FAT %	5.00 (0.50 - 26.00)	6.01 ± 4.23

Figure 1: Age and gender distribution of study population

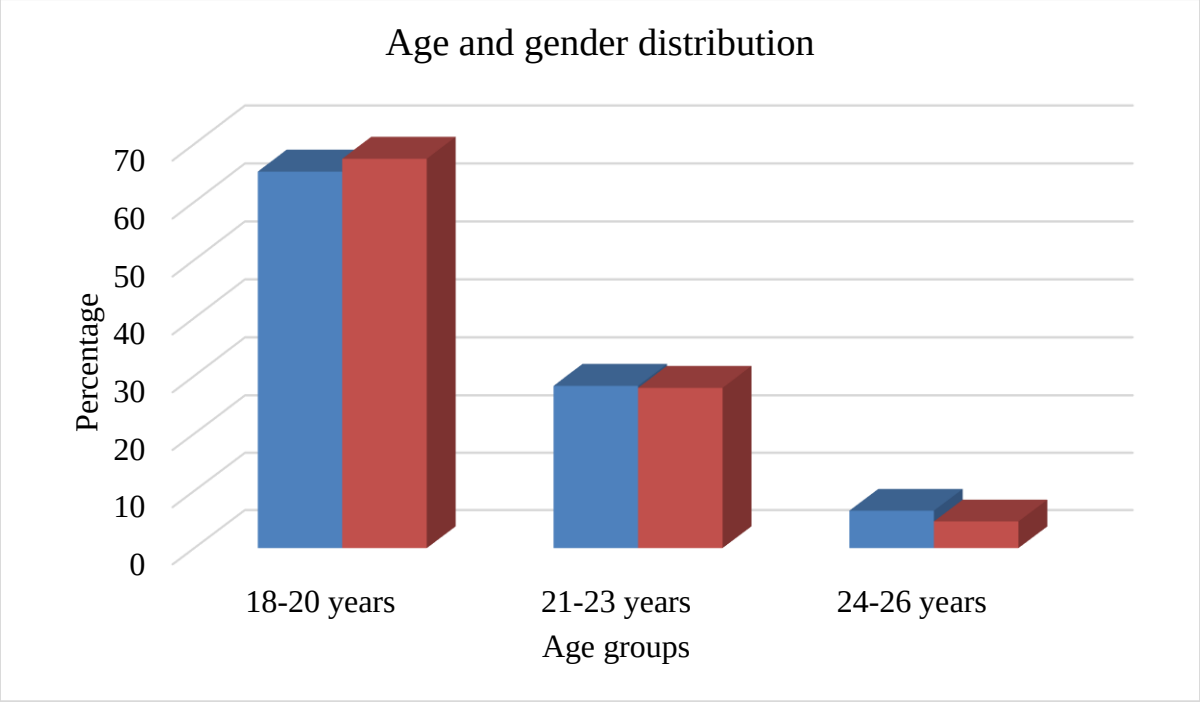
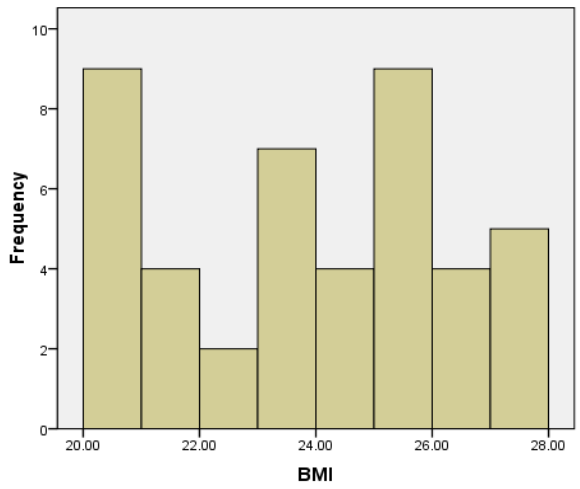


Table 2: Observed yy phenomenon for studied indices.

yy phenomenon	No. of subjects showing yy phenomenon (n=89)	Gender Distribution			Frequency of yy	
		Male (n=46)	Female (n=43)	Both gender yy (male-female with same value)	2 individuals with yy	≥ 3 individuals with yy
Classic YY Paradox	44 (49.44%)	16 (34.78%)	11 (25.58%)	17 (38.64%)	32 (72.73%)	12 (27.27%)
yy BVI~BMI	47 (52.81%)	21 (45.65%)	13 (30.23%)	13 (27.66%)	26 (55.32%)	21 (44.68%)
yy SKM/BF ~ BV	34 (38.20 %)	16 (34.78%)	18 (41.86%)	0 (0.00%)	22 (64.71%)	12 (35.29%)
yy LBM/BF ~ BV	26 (29.21%)	6 (13.04%)	20 (46.51%)	0 (0.00%)	16 (61.54%)	10 (38.46%)

Figure 2: Distribution of yy-phenomenon in studied indices

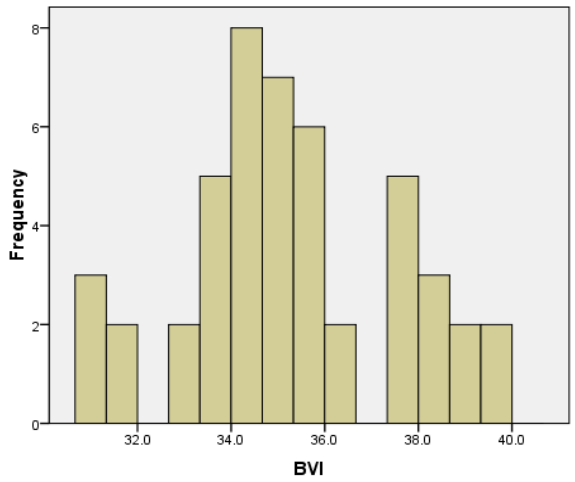
CLASSIC YY paradox (N=44)



Skewness= - 0.151

Kurtosis= - 1.273

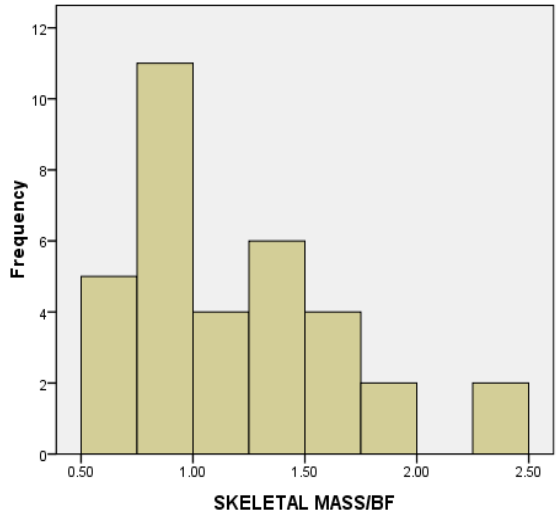
yy BVI~BMI (N=47)



Skewness= 0.041

Kurtosis= - 0.335

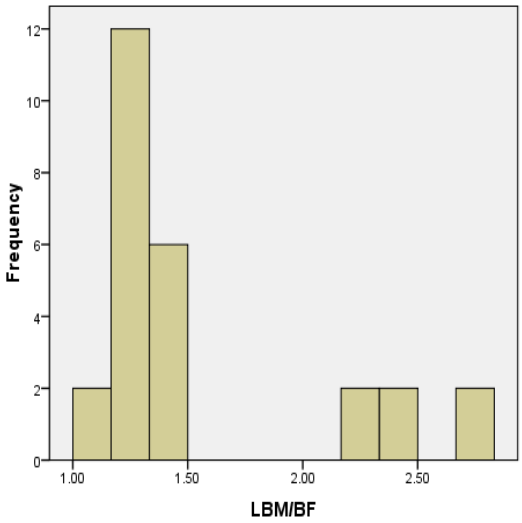
yy SKM/BF ~ BV (N=34)



Skewness= 1.031

Kurtosis= 0.492

yy LBM/BF ~ BV (N=26)



Skewness= 1.440

Kurtosis= - 0.531

Figure 3: Association of Visceral fat and waist circumference, in study population

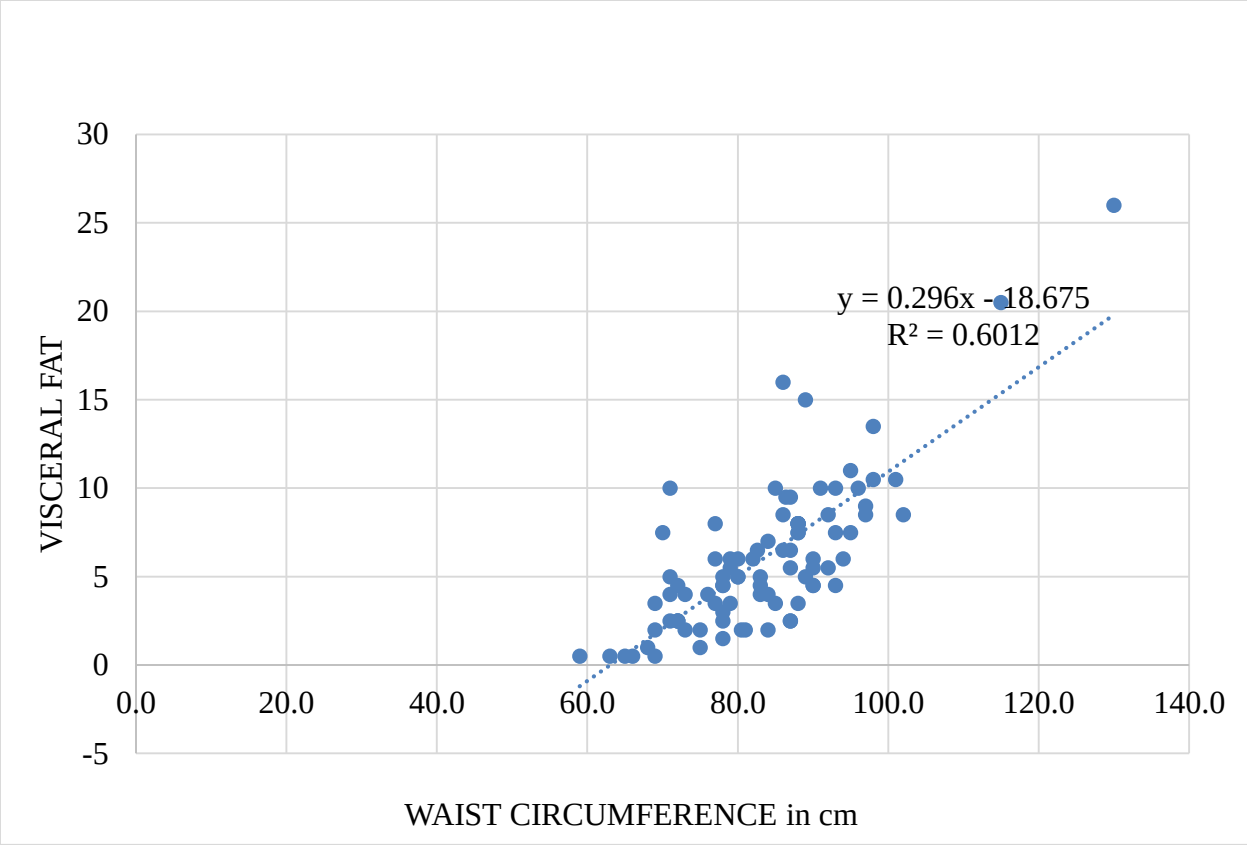


Table 3: Odds of high/ very high visceral fat in studied indices among subjects with or without yy-phenomenon

yy-phenomenon	Classic YY Paradox	yy BVI ~ BMI	yy SM/BF ~BV	yy LBM/BF ~ BV
Total yy	44 (49.44%)	47 (52.81%)	34 (38.20 %)	26 (29.21%)
yy with High/ Very High VF	4 (9.09%)	3 (6.38%)	1 (2.94%)	4 (15.38%)
Total Non yy	45	42	55	63
Non yy with High/ Very High VF	9 (20%)	10 (23.81%)	12 (21.82%)	9 (14.2%)
OR (C.I.)	0.400 (0.120-1.345)	0.218 (0.060- 0.804)	0.109 (0.017- 0.695)	1.091 (0.323- 3.738)