YY Paradox: Findings from a Community Based Study in North India

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ABSTRACT

Background: Body Mass Index (BMI) has been widely accepted as an indicator for assessment of obesity. 3D scan of body composition parameters of Yajnik and Yudnik, the two authors who had similar BMI but different body fat percentage was labeled as 'YY paradox'.

Objective: to explore the nature and usage of YY paradox in women.

Methods: A cross-sectional study was conducted among 301 women in the age group 25-64 years in rural area in Barabanki district. Body composition 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), and 3) same Lean Body mass/body fat but different body volume (yy LBM/BF~ BV).

Results: The mean age of women (n=301) was 41.69 ± 11.86. Odds Ratio (OR) for high visceral fat in all the studied indices among subjects showing yy-phenomenon and those not showing yy-phenomenon revealed highest OR of 5.25 (CI 2.86-9.61) for yy LBM/BF ~ BV index.

Conclusion: A high percentage of three paradoxes was found in this population and also demonstrated that these are not normally distributed. It is also felt that a deeper look in this aspect could be used for deriving predictive models for anthropometric markers linked to various diseases.

Keywords: Paradox; Bioelectric; Impedance; Indices

INTRODUCTION

The analysis of health and nutrition data from various countries shows many surprising and seemingly incomprehensible facts and paradoxical relationships.[1] Body mass index (BMI) which was being used for many years for assessing obesity/nutritional status was discredited by YY paradox. Yajnik and Yudnik the two authors, had a near identical body-mass index (BMI), but dual X-ray absorptiometry imaging showed that the first author had substantially more body fat than the second author. Lifestyle may be relevant: the second author used to run marathons whereas the first author's main exercise was running to beat the closing doors of the elevator in the hospital every morning. This gained fame as YY paradox.[2] Emerging technology of 3D scan for measuring body fat paved the way for a new index called body volume index (BVI).[3] BVI has significant implications for public health. Bihari et al demonstrated an association between mathematically derived BVI and musculoskeletal pain among house wives of Delhi.[4]

In this study, YY phenomenon or paradox has been considered when two or more people have same anthropometrically derived index but have

different body composition parameter. 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.[5] In spite of conceptualization of YY paradox; there is paucity of information regarding its extent and implications in human population.

About seven decades 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.[6] 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.[7] The present study is an attempt to find out extent, nature and uses of yy-phenomenon in women (25-64 years) of North India, based on some commonly used body composition parameters

MATERIAL AND METHODS

Study design and area

This community based cross-sectional study was conducted in villages under Rural Health Training Centre (RHTC) of Department of Community medicine, Hind Institute of Medical Sciences situated in Barabanki district of Uttar Pradesh. The study was conducted during the month of May-December, 2016.

Participants of the study

All women in the age group 25-64years, residing in the study area for at least 6 months constituted the universe of the study. The sample size was computed to be 290 (≈ 301) considering a prevalence rate of 74.8% (abdominal obesity among women),[8] with absolute precision of 5%. Multistage sampling was done to select participants.

Data collection

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. Sociodemographic characteristics of subjects were assessed by interviewing them with the help of predesigned and pretested proforma. 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 method (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 (>9.5-14.5) and very high (>14.5-30.0). BF% was classified as normal (20-<30%) and high/obese and overweight (≥30). BMI was classified as normal (18.5-24.99) and high/obese and overweight (>25).[9] Height, weight and waist circumference were measured as per standard methods.[10]

The indices used in this study and their derivations were:

1. BSA (Body Surface Area)[11] was calculated using formula BSA = 0.007184 x Weight (kg)$^{0.425}$ x Height (cm)$^{0.725}$
2. Body Volume Index[12]-BVI (V/S) was calculated using formula BVI = S (51.44W/H + 15.3) where W= weight in kg, H=height in cm, S= body surface area in m^2
3. Body Volume (BV) was calculated as product of BVI and BSA
4. Lean Body Weight (men)[13] = (1.10 x Weight(kg)) - 128 x (Weight^2/(100 x Height (m))^2) Lean Body Weight (women) = (1.07 x Weight (kg)) - 148 x (Weight^2/(100 x Height(m))^2)

All the yy-phenomenon for following body composition parameters were identified among the study population:

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

Data were compiled and analyzed using MS Excel. Odds ratio was used to show relation between high/very high visceral fat among the two groups (subjects with yy and without yy).

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the author. 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.

RESULTS

The mean age of women (n=301) was 41.69 ± 11.86. Majority of women were of Hindu religion (96.67%) and OBC caste (85.22%). More than half of subjects (61.8%) were from joint families. Majority

of the females were married (94%) and only 2.7% were widows. Over 40% females belonged to lower and lower middle class. Fifty one percent of the females were illiterate. Eighty nine percent of females were homemakers, 5% were farmers and 2% were government employee.

The median and range for studied body composition parameters and indices of the study subjects are shown in Table 1. High/very high visceral fat was found among 21.2% study subjects. In 21.9% and 74.4% subjects, BMI and BF% were high [Table 2]. yy BMI ~ BF was found in 236 individuals (78.40%), 86 individuals (28.57%) had yy- phenomenon of same BVI but different BMI. Of all the indices studied, lowest number of yy-phenomenon was found in index yy LBM/BF ~ BV(22.26%) as shown in Table 3. The distribution of the yy-phenomenon for the three studied body indices was found to be positively skewed as shown in Figure 1.

Waist circumference (WC) is widely used as an indirect measure of abdominal adiposity in epidemiological studies.[14] Figure 2 depicts a good association of visceral fat with waist circumference in this population.

Odds Ratio (OR) was calculated for high visceral fat in all the studied indices among subjects show-ing yy-phenomenon and those not showing yy-phenomenon. Highest OR of 5.25 (CI 2.86-9.61) was found 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)

Table 1: Body composition measurements among the study subjects (N=301)

Body composition parameters	Median	Range
BMI	21.7	14.2 - 35.5
Body fat%	34.7	15 - 49.9
Visceral fat%	5.5	0.30 - 30
Skeletal mass%	35.60	25.63 - 48.97
Body Surface area (m²)	5.16	4.23 - 6.61
Body volume (in litres)	44.41	29.02 - 80.17
Body Volume Index	31.88	25.87 - 43.58

Table 2: Distribution of study subjects according to their body composition parameters (N=301)

Parameters	Low (%)	Normal (%)	High (%)
BMI	63 (20.9)	172 (57.2)	66 (21.9)
Body fat%	9 (3)	68 (22.6)	224 (74.4)
Visceral fat%	2 (0.6)	235 (78.2)	64 (21.2)

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 LBM/BF~BV
Total yy	236 (78.40)	86 (28.57)	67 (22.26)
yy with High/Very high VF	51 (21.61%)	13 (15.11%)	31 (46.27%)
Total Non yy	65 (21.60%)	215 (71.43%)	234 (77.74%)
Non yy with High/Very high VF	13 (20%)	51 (23.72%)	33 (14.10%)
OR (C.I.)	1.103 (0.56 – 2.18)	0.57 (0.29 – 1.12)	5.25 (2.86 – 9.61)

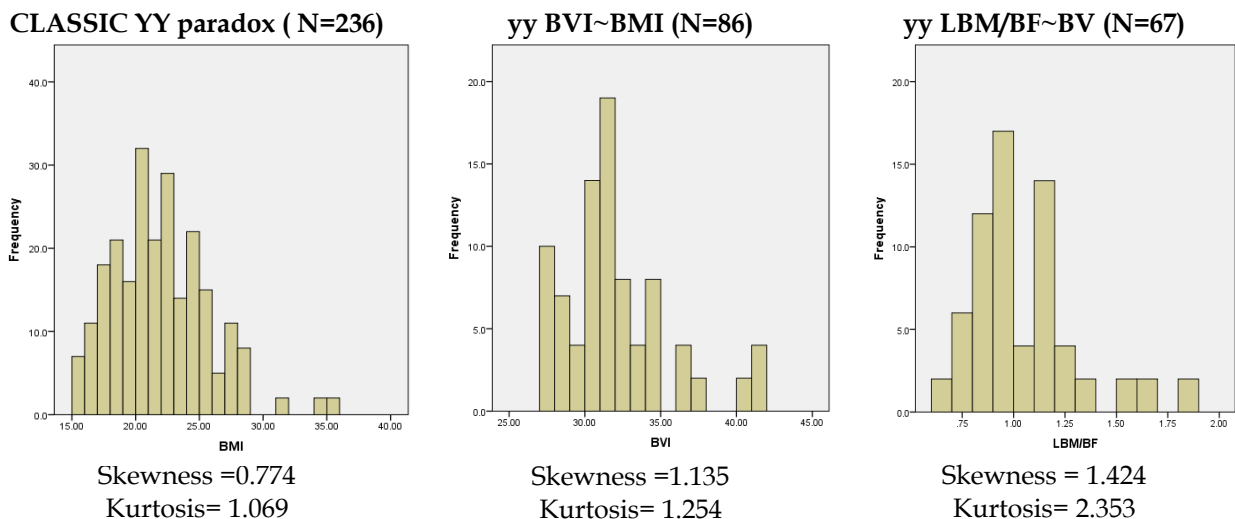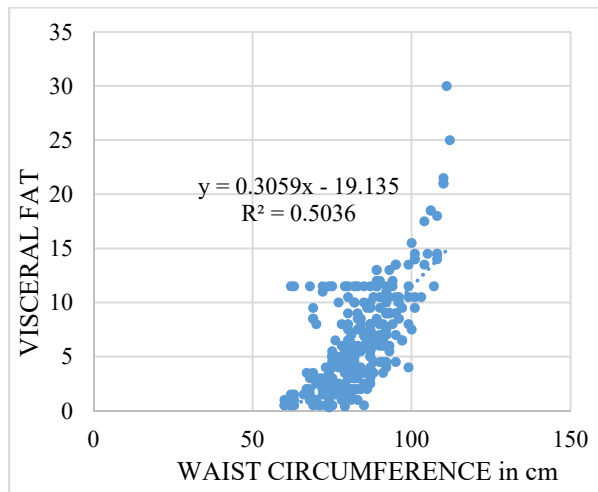**Fig 1: Distribution of yy phenomenon among the subjects**

CLASSIC YY paradox (N=236)
Skewness =0.774
Kurtosis= 1.069

yy BVI~BMI (N=86)
Skewness =1.135
Kurtosis= 1.254

yy LBM/BF~BV (N=67)
Skewness = 1.424
Kurtosis= 2.353

Fig 2: Association of Visceral fat with waist circumference among the study subjects

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 study subjects with high visceral fat. It is hypothesized that subjects of this age group and economic status in this area would have approximate prevalence of abdominal obesity that is roughly equal to the prevalence of yy-phenomenon in yy LBM/BF ~ BV. More detailed studies are needed to substantiate this hypothesis.

Research shows that abdominal adiposity is positively related to cardiovascular disease (CVD) risk.[15] this approach could be used for finding prevalence of abdominal obesity, in even in small sample of population.

The limitation of the study is its confinement to one setting and therefore could not be examined in a wider horizon. This issue needs exploration through multicentric studies.

DISCUSSION

YY paradox was introduced by Yajnik and Yudkin to highlight the fact that people with same BMI may have very different body components. It has been used by 3D scan manufacturers for highlighting the difference in fat percentages among people with same BMI. On this ground, the study has been conducted on three different body indices.

Hollywood celebrities Dita Von Teese and Jessica Biel have a BMI of 16.6.[15] moving a step ahead, persons with same height, weight and thus same BMI may have differe body compositions parameters. Graphs showing such paradoxes are available on the internet.[16] Gomez-Ambrosi et al,[17] assessed the BMI, body fat percentage, and cardio-metabolic risk factors of among 6123 Caucasian subjects(69% females) between the ages of 18 and 80 years and classified these according to BMI into 15.09% lean, 26.74% overweight and 58.17% obese. 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 persons for parameters like BMI, body fat, visceral fat, body volume index and lean body mass have been described here. This study demonstrated that these are not normally distributed. This was in consonance with findings of Penman and Johnson.[18] Furthermore, all the studied indices showed a prevalence of yy-phenomenon ranging from 22.78 – 78.4%. The lowest prevalence of 22.26% yy-phenomenon was observed in index of yy LBM/BF ~ BV. As yy- phenomenon leads to confusion about actual body type, any indicator

CONCLUSION

YY paradox prevailed in anthropometric data and body composition indices of women. This type of data does not follow the normal Gaussian distribution.

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