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SENSITIVITY OF BODY MASS INDEX(BMI)) CUT OFF'S IN PREDICTING PERCENT BODY FAT IN SAUDI YOUNG FEMALE POPULATION

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ABSTRACT

Objectives: To study the association of BMI with percent fat ranges and to examine if obesity markers other than BMI have higher predictability in identification of high risk groups as defined by metabolic measurements among female college students and employees in Hail, Northern part of Saudi Arabia. **Methodology:** Sample of 514 female college students and employees were enrolled and body composition was measured by using bioelectrical impendence technique. Blood pressure (BP) and pulse were measured using automatic BP reader in a resting sitting position. Random blood glucose was tested using strip method (One touch, Simple). **Results:** Mean BMI was in overweight category while BF%, WHR were in high risk range for the study sample. Collectively, 46.7% of the study subjects were overweight and obese. Majority of the subjects (71.8 %) were in high risk WC, WHR group and high %BF (85.6 %). In underweight BMI group 66.1 % had normal BF% and around 23.2 % had high BF% while in female normal BMI group only 14.2 % have normal BF% while nearly 85.8 % have high BF%. Results indicate the inability of BMI classification in predicting the normal ranges for WHR, WC and VF. Misclassification is higher in underweight and normal weight categories as compared to overweight category. Blood pressure and blood glucose had linear relationship for all obesity markers studied with underweight having lowest ranges as compared to obese groups having highest ranges. However the associations were not significant for blood glucose with WHR and %BF. Pulse had inverse relationship with low risk groups having higher values as compared to high risk groups for all obesity markers. **Conclusion:** Our findings suggest BMI showed low sensitivity for detecting body fatness, especially in normal BMI category. The true prevalence of obesity may be higher than estimated in populations using only BMI as surrogate marker.

KEYWORDS: Blood pressure (BP), BMI, WC, WHR and VF.

INTRODUCTION

The Kingdom of Saudi Arabia (KSA) is having majority of population as young adults who are below the age of 30 years.[1] KSA is also among the countries which witnessed rapid socio economic development during past few decades. Urbanisation of KSA has lead to complex changes in life style patterns which resulted in increased rates in morbidity and mortality due to chronic diseases.[2, 3] Along with these trends there was a sharp rise in obesity in KSA.[4] The available literature indicates that obesity is emerging as a major health problem with approximately three quarters of females and nearly two-thirds of males of adult population in the Kingdom being either overweight or obese.[5] Younger populations are affected by increasing rates of obesity while some studies also indicate regional disparities in the prevalence of obesity.[4, 6]

Young adults represent a period of various important transitions relevant to later life and health with explicit lifestyle priority issues, calling for specific strategies and approaches. Research suggests the ages of 18 to 29 years, a transition period from adolescence to adulthood are vulnerable for rising obesity rates.[2] and young women notably having higher prevalence of overweight and obesity as compared to males.[7, 8]

Obesity traditionally defined by Body mass index (BMI) may not accurately represent the complex scenario of obesity. Body composition Analysis is opening up new paradigm shift in our understanding related to differences in phenotypes which can explain complex obesity.

In view of the foregoing observations, the present investigation was undertaken to assess the prevalence of overweight and obesity along with body composition analysis in a sample of female students from the University of Hail (UOH) in Hail City, KSA.

Objectives

1. To analyse body composition patterns, blood pressure and blood glucose levels among study subjects

2. To study the association of BMI with percent fat ranges.
3. To examine if obesity markers other than BMI have higher predictability in identification of high risk groups as defined by metabolic measurements.

Significance of the Present Study

There are very few studies done from Saudi Arabia investigating the relationship of BMI classification with percent body fat (% BF) ranges. High BMI, percent body fat, waist hip ratio (WHR) and visceral fat are all highly correlated with substantial increase in CVD risk. In addition we also studied the blood pressure, pulse, blood glucose which also contribute significantly to CVD risk at higher levels. Hence the results of this study will generate information which has public health significance and also can provide basis for proactive health measures both at public and personal level.

Methodology

Study design

A cross sectional survey was planned and conducted in female campus of University of Hail, Hail, KSA during Sep., 2013 to Nov., 2013.

Sample

Approximately, a random sample size of 514 female students and employees (representing both Science and Humanities Colleges) participated in the survey. Posters were pasted throughout college informing the days of data collection and who ever visited labs were included in the study. Exclusion criteria followed included females with pregnancy, lactation and menstruation cycle during examining days.

Ethics

All enrolled participants were briefed about the purpose of the study and were required to provide a written informed consent before participating in the study. The study protocol was approved by University of Hail Committee on Human Research Ethics.

Data collection methods

For body composition analysis, subjects were to undergo bioelectric impedance analysis (BioSpace, Inbody 720) for anthropometric measurements. Manufacturer's instructions were followed strictly for accurate measurement with InBody 720. WHO classification was followed for Body mass index (BMI) stratification. Waist hip ratio (WHR) was used to identify the study population into low and high risk groups (cut-off for females ≥ 0.85). Normal ranges for percent body fat (BF%) were considered as follows:18–28 % for females and for visceral fat as ≤ 100 cm as suggested from manufacturers of Inbody 720. Blood pressure (BP) and pulse were measured using automatic BP reader in a resting sitting position. Subjects were made to relax for 10 minutes before taking BP measurements. Random blood glucose was tested using strip method (One touch, Simple).

Statistical analysis

The data set was cleaned and edited for inconsistencies. Missing data were not statistically computed. Statistical analyses were performed using the Statistical Package for Social Sciences (version 16.0, SPSS, Inc) software. Descriptive statistics such as means and standard deviations were calculated for the continuous variables and frequencies for qualitative data. Analysis of variance (ANOVA) and chi-square analysis was used to examine differentials in variables. Results were expressed as either mean ± SD or counts and percentages. All reported P values were 2-sided and differences were considered statistically significant at $P<0.05$.

RESULTS

Statistical analysis for the study sample of 514 has been presented in this section. Table 1 presents the mean ± SD of age, blood pressure and blood glucose levels of the study subjects. Mean age of the study subjects was 23 since majority of the subjects participated in the study were students as compared to employees of the university. Mean values of BP and blood glucose were within normal ranges. Mean pulse rate was very high given the young age of the majority subjects participated in the study.

Table 1: Mean age, blood pressure, pulse and blood glucose of the subjects

	Mean	Standard Deviation
Age (yr)	23	6
SBP (mm Hg)	111	15
DBP (mm Hg)	72	9
Pulse (BPM)	83	11
Glucose (mg/dl)	101	24

Table 2 presents body composition analysis of the subjects (mean ± SD). Body composition analysis was done for body water, protein, mineral, soft lean mass, skeletal muscle mass, BMI, percent body fat, WHR and visceral fat. The mean height of the subjects was 158 cm and mean weight was 64 kg. Mean BMI was in overweight category while BF%, WHR were in high risk range. For visceral fat the maximum normal cut-off suggested by Inbody manufacturers was 100 cm. In the present study the subjects mean visceral fat was close to maximum cut off level. Inbody machine provides 4 body compartmental analysis and provides information related to protein, mineral, osseous mineral, fat free mass, skeletal muscle mass which help to correlate to nutritional status of the subjects.

Table 2: Body composition analysis of the subjects

	Mean	Standard Deviation
Height (cm)	158	5
Weight (kg)	64.1	16.4
Total Body Water (l)	28.0	4.0
Protein (kg)	7.5	1.1
Mineral (kg)	2.72	0.37
Osseous Mineral (kg)	2.27	.30
Body Fat Mass (kg)	25.8	11.9
Fat free mass (kg)	38.2	5.5
BMI (kg/m^2)	25.59	6.31
Skeletal Muscle Mass (kg)	20.5	3.2
Percent Body Fat (%)	38.5	8.9
WHR	0.89	0.07
Waist Circumference (WC)	87.02	15.38
Visceral fat (cm)	98.0	47.3

Table 3 presents distribution of study population into BMI, %BF and WHR groups. Collectively, 46.7% of the study subjects were overweight and obese, with 24.5 % of the total subjects being overweight (BMI 25- 29.99) while 22.2 % were obese (BMI≥30). Majority of the subjects (71.8 %) were in high risk WC, WHR group and high %BF (85.6 %).

Table 3: BMI, %BF, WC and WHR in the study population *(n* (%))

Category	Females (*n*=514)
Underweight	56 (10.9)
Normal BMI	218 (42.4)
Overweight	126 (24.5)
Obese	114 (22.2)
Low risk WHR (females ≤ 0.84)	145 (28.2)
High Risk WHR group (females ≥ 0.85)	369 (71.8)
Low risk WC (females ≤ 87.99 cm)	295 (57.4)
High risk WC (females ≥ 88 cm)	219 (42.6)
Normal BF % (≤ 28 for females)	74 (14.4)
High BF % (≥ 28.1 % for females)	440 (85.6)
Low risk visceral fat (≤ 99.9 cm)	308 (59.9)
High risk visceral fat (≥ 100 cm)	206 (40.1)

Table 4 presents mean BMI, BF%, WHR, waist circumference (WC) and visceral fat (VF) across BMI groups, which were significantly lowest ($P<0.01$) for underweight and highest for obese groups.

Table 4: BMI, BF%, WHR, Waist Circumference (WC) and Visceral fat (VF) according to BMI groups (Mean±SD)

BMI Groups (*n*)	BMI	BF %	WHR	WC	VF
Underweight (56)	17.27 ± 0.99	24.69 ±4.40	0.78 ±0.02	66.00 ± 2.89	48.43± 11.42
Normal BMI (218)	21.87 ± 1.82	33.85 ± 5.01	0.85± 0.03	77.95 ± 5.01	71.82 ± 18.51
Overweight (126)	27.18 ± 1.40	42.19 ± 3.57	0.92 ± 0.02	91.74 ± 3.96	107.31 ± 21.66
Obese (114)	35.02 ± 4.27	49.19 ± 3.77	0.98 ± 0.03	109.49 ± 9.57	159.45 ± 42.76

However Table 5, 6, 7 and 8 signifies that body composition analysis assures better recognition of body fat content than BMI alone. It is evident from this Table 5 that the distribution of BF% varies for BMI groups. In underweight BMI group 66.1 % had normal BF% and around 23.2 % had high BF% while in female normal BMI group only 14.2 % have normal BF% while nearly 85.8 % have high BF%. Both overweight and obese groups have 100 percent high BF%. Similarly Table 6, 7 and 8 suggest the inability of BMI classification in predicting the normal ranges for WHR, WC and VF. Misclassification is higher in underweight and normal weight categories as compared to overweight category. Obese BMI cutoff was able to predict the high risk groups accurately for all obesity markers like %BF, WHR, WC and VF.

Table 5: BF% in the study subjects according to their BMI group *n* (%)

BMI group	Low BF% ≤ 17 for females)	Normal BF% (18-28 for females)	High BF% (≥ 29 % for females)
Underweight	6 (10.7)	37 (66.1)	13 (23.20)
Normal	0	31 (14.2)	187 (85.8)
Overweight	0	0	126 (100)
Obese	0	0	114 (100)

Table 6: WHR in the study subjects according to their BMI group *n* (%)

BMI group	Low risk WHR (females ≤ 0.84)	High Risk WHR group (females ≥ 0.85)
Underweight	56 (100)	0
Normal	89 (40.8)	129 (59.2)
Overweight	0	126 (100)
Obese	0	114 (100)

Table 7: WC in the study subjects according to their BMI group *n* (%)

BMI group	Low risk WC (females ≤ 87.99 cm)	High risk WC (females ≥ 88 cm)
Underweight	56 (100)	0
Normal	216 (99.1)	2 (0.9)
Overweight	23 (18.3)	103 (81.7)
Obese	0	114 (100)

Table 8: VF in the study subjects according to their BMI group *n* (%)

BMI group	Low risk visceral fat (≤ 99.9 cm)	High risk visceral fat (≥ 100 cm)
Underweight	56 (100)	0
Normal	201 (92.2)	17 (7.8)
Overweight	49 (38.9)	77 (61.1)
Obese	2 (1.8)	112 (98.2)

Table 9 presents blood pressure, pulse and blood glucose in the study subjects according to their BMI, WHR, WC, %BF and VF groups. Blood pressure and blood glucose had linear relationship for all obesity markers studied with underweight having lowest ranges as compared to obese groups having highest ranges. However the associations were not significant for blood glucose with WHR and %BF. Pulse had inverse relationship with low risk groups having higher values as compared to high risk groups for all obesity markers. All associations were statistically significant.

Table 9: Blood pressure, pulse and blood glucose in the study subjects according to their BMI, WHR, WC, %BF and VF groups.

Category	SBP	DBP	Pulse	Glucose
Underweight	104.50 ± 12.04	68.61 ± 8.45	89.11 ± 10.24	100.48 ± 14.967
Normal BMI	107.61± 10.80	70.56 ± 8.06	82.92 ± 11.20	98.15 ± 17.449
Overweight	110.76± 14.37	72.19 ± 9.26	82.87 ± 10.83	104.17 ± 35.130
Obese	121.87± 19.11	76.90 ± 10.82	80.51 ± 11.09	106.30 ± 31.930
F Value	30.975*	15.502*	7.734*	2.938*
Low risk WHR (females ≤ 0.84)	105.72 ± 11.90	69.31 ± 8.41	85.84 ± 11.31	98.60 ± 15.11
High Risk WHR group (females ≥ 0.85)	113.36 ± 16.04	73.27 ± 9.61	81.96 ± 10.98	102.90 ± 29.45
F Value	27.442*	18.806*	12.737*	2.796
Low risk WC (females ≤ 87.99 cm)	107.11 ± 11.13	70.22 ± 8.15	84.37 ± 11.35	98.68 ± 16.67
High risk WC (females ≥ 88 cm)	116.75 ± 18.02	74.78 ± 10.42	81.26 ± 10.76	105.73 ± 34.93
F Value	55.625*	30.824*	9.841*	9.199*
Normal BF % (≤ 28 for females)	106.59 ± 12.32	69.64 ± 8.96	86.62 ± 11.75	100.24 ± 14.78
High BF % (≥ 28.1 % for females)	112.00 ± 15.53	72.58 ± 9.47	82.45 ± 11.00	101.93 ± 27.74
F Value	8.082*	6.231*	8.944*	0.260
Low risk visceral fat (≤ 99.9 cm)	107.53 ± 11.18	70.55 ± 8.14	83.86 ± 11.17	99.13 ± 16.77
High risk visceral fat (≥ 100 cm)	116.73 ± 18.49	74.57 ± 10.68	81.84 ± 11.16	105.50 ± 35.78
F Value	49.057*	23.162*	4.015*	7.363*

DISCUSSION

Obesity is a risk factor for many chronic diseases like diabetes, hypertension, heart disease, stroke, and cancer.[9] Increased obesity in mid-life especially women is associated with reduced health in long term.[10] Obesity therefore has become primary address for prevention efforts at both public as well as individual level. Thus, clinical detection of obese individuals has commensurately reached critical importance.

BMI, or Body Mass Index, is a simple formula using a person's height and weight to calculate a value which is supposed to be representing body fat level. It has gained immense popularity in epidemiological studies owing to its simplicity in measurement and non invasive nature. However recent studies indicate BMI may not be an accurate indicator of body fat especially in normal weight categories.[11]

The results of our study, involving a 514 women sample, demonstrates that BMI has a limited diagnostic performance to correctly identify individuals with excess in body fatness, particularly for those with BMI between 18.5 to 25 kg/m2. The sensitivity of BMI $\geq$ 25 kg/m2 to diagnose obesity is relatively low, missing more than 80 percent of people with BF % defined obesity and around 50 percent of people with WHR defined obesity. However normal BMI cutoff is able to differentiate efficiently majority people with WC and VF defined obesity.

The BMI classifications of overweight and obesity reflect risk for type 2 diabetes and cardiovascular diseases, which are rapidly becoming major causes of death in adults in all populations. However, prevalence and incidence of type 2 diabetes and CVD risk varies in populations with similar BMI’s.[12] The study results have also indicated that all obesity surrogate markers like BMI, WHR, %BF, WC and VF were able to detect possible risk with increasing obesity for high blood pressure values. However for hyperglycemia as tested using rapid capillary blood glucose levels only BMI, WC and VF were able to differentiate and WHR and %BF couldn’t find any significant differences for respective normal and high groups. One interesting finding in the study was pulse levels were consistently having inverse linear association with all studied obesity markers. This need to be further explored to understand the physiological processes which may be responsible for this phenomenon.

Limitations

Inclusion of a control group with established metabolic syndrome, hypertension or diabetes and analysis of more CVD risk factors like lipid profile and lifestyle factors like physical activity and diet history would have given more weight to the results.

CONCLUSION

Our findings suggest BMI showed low sensitivity for detecting body fatness, especially in normal BMI category. The true prevalence of obesity may be higher than estimated in populations using only BMI as surrogate marker. Further body composition studies are needed to determine fatness and their relation to BMI in different ethnic groups and genders and will help develop population specific cut-offs to identify CVD risk factors.

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