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Research Article

Estimation of body mass index and risk evaluation of diabetes and cardiovascular diseases in undergraduate students

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ABSTRACT

Background: The body mass index (BMI) is used in a wide variety of contexts as a simple method to assess how much an individual's body weight departs from what is normal or desirable for a person of his or her height. An increase in body fat is generally associated with increased risk of metabolic diseases such as type 2 diabetes mellitus, hypertension and dyslipidaemia.
Methods: The study conducted on the undergraduate medical students was a cross-sectional analytical study. The BMI was calculated using the formula, BMI = Body Mass (kg)/Height (m^2). The blood pressure (systolic and diastolic), blood sugar levels (fasting blood sugar) and fasting lipid levels were measured for the overweight and obese groups.
Results: A total of 305 students participated in the study. The mean BMI was 21.47 with a standard deviation of 3.42. 218 (71.47%), were in the healthy, 26 (8.52%) were in the overweight and 6 (1.96%) were in the obese categories. 16 (61.5%) of the overweight subjects were prehypertensives. 4 (66.7%) of the obese subjects were hypertensives. 2 (7.69%) out of the 26 overweight subjects were in prediabetic stage. 22 (84.61%) of the overweight and 5 (83.33%) of the obese subjects had dyslipidaemias.
Conclusions: The prevalence of being overweight and obese among undergraduate medical students is a matter of serious concern. This reflects on the students' poor dietary habits and inadequate physical activity. A serious approach to reduce body weight through dietary modifications and regular physical activity is the need of the hour.

Keywords: Body Mass Index, Prehypertension, Hypertension, Prediabetes, Diabetes, Dyslipidaemias, Overweight, Obese

INTRODUCTION

The body mass index (BMI), or Quetelet index, is a measure for human body shape based on an individual's mass and height. Devised between 1830 and 1850 by the Belgian polymath Adolphe Quetelet during the course of developing "social physics",[1] it is defined as the individual's body mass divided by the square of their height – with the value universally being given in units of kg/m^2.

Body mass index = Body mass (Kg)/Height (m^2)

The BMI is used in a wide variety of contexts as a simple method to assess how much an individual's body weight departs from what is normal or desirable for a person of his or her height. The BMI ranges are based on the relationship between body weight and disease and death.[2,3] BMI has recently gained favour as a better measure of adiposity.[4,5]

Table 1: The international classification of adult underweight, overweight and obesity according to BMI.

CATEGORY	BMI range – kg/m^2
Very severely underweight	less than 15
Severely underweight	from 15.0 to 16.0
Underweight	from 16.0 to 18.5
Normal (healthy weight)	from 18.5 to 25
Overweight	from 25 to 30
Obese Class I (Moderately obese)	from 30 to 35
Obese Class II (Severely obese)	from 35 to 40
Obese Class III (Very severely obese)	over 40

(Adapted from WHO, 1995; WHO, 2000 and WHO, 2004)

Health consequences of overweight and obesity in adults

Overweight and obese individuals are at increased risk for many diseases and health conditions, including the following:[6,7]

1. Hypertension.
2. Dyslipidemia. (for example, high LDL cholesterol, low HDL cholesterol, or high levels of triglycerides)
3. Type 2 diabetes.
4. Coronary heart disease.
5. Stroke.
6. Gallbladder disease.
7. Osteoarthritis.
8. Sleep apnea and respiratory problems.

Obesity is a direct risk factor for cardiovascular disease[7] and an indirect risk factor because of its effects on diabetes, hypertension, and hyperlipidemia.[7]

An increase in body fat is generally associated with increased risk of metabolic diseases such as type 2 diabetes mellitus, hypertension and dyslipidaemia. (World Health Organization. Obesity and Overweight Facts, (March 2007).

Increased BMI was associated with increased prevalence of diabetes mellitus, hypertension and dyslipidaemia in both these studies. ($p < 0.001$).[8]

The occurrences of Type II Diabetes have been reported in children, adolescents and young adult age group individuals.[9-15] The occurrence of hypertension, dyslipidemia, type 2 diabetes and metabolic syndrome has been reported in children, adolescents and young adults.[16,17] Obesity has now become a critical problem in the U.S., with the prevalence among adults increasing by nearly 50% during the 1980s and 1990s;[18] now, nearly 70% of adults are classified as overweight or obese compared with fewer than 25% 40 years ago.[18,19,20] Additionally, the distribution of BMI in the U.S. has shifted in a skewed fashion such that the proportion of the population with morbid obesity has increased by a greater extent than overweight and mild obesity.[18,20,21,22]

Recent evidence indicates that obesity is associated with more morbidity than smoking, alcoholism, and poverty, and if current trends continue, obesity may soon overtake cigarette abuse as the leading cause of preventable death in the U.S.[19,20,23] Should we fail to stop the obesity epidemic, it has been predicted that we may soon witness an abrupt end, or even a reversal, of the steady increase in life expectancy.[23,24]

Obesity has reached epidemic proportions in the 21st century in India, with morbid obesity affecting 5% of the country's population. India is following the trend of other developing countries that are steadily becoming more obese.[25]

This study aims to estimate the prevalence of overweight and obesity in the undergraduate medical students and also to study the correlation between an increased BMI with blood pressure, fasting blood sugar and fasting blood lipid levels.

The undergraduate medical students were selected as the study population since many studies have revealed an increase in the prevalence of obesity in the young adult population as well as a rise in the incidences of hypertension, diabetes and dyslipidaemias in this population.

Aims and objectives of the present study:

1. To assess the pattern of distribution of BMI among undergraduate medical students.
2. To explore the relationship between body mass index (BMI) and blood pressure, blood sugar and lipid levels in medical students categorized as overweight and obese.
3. Timely intervention in the form of life style modifications such as good eating habits, physical exercises, aimed at reducing body weight in the overweight and obese students, to reduce the chances of getting afflicted with hypertension, diabetes or other cardiovascular disease in the future.
4. Pharmacological interventions in students diagnosed with hypertension, diabetes mellitus or hyperlipidemia.

METHODS

Study design and participants

The study conducted was a cross-sectional analytical study. Undergraduate students from the 1st, 2nd, 3rd, 4th

and the 5th year studying in Adichunchanagiri Institute of Medical Sciences, B. G. Nagar, Mandya (district), Karnataka were included in our study.

Study site

The study was conducted at the Department of Pharmacology, Sri Adichunchanagiri Institute of Medical Sciences, B. G. Nagar, Mandya district, Karnataka.

Duration of the study

The study was done in the months of July, August and September, 2014.

Number of subjects recruited in the study

A total of 305 students participated in this study.

Sample size

All the students of Adichunchanagiri Institute of Medical Sciences who were available during the study were included.

Inclusion criteria

Medical students who were willing to give informed consent of both sexes were included in the study.

Exclusion criteria

Medical students on anti-hypertensive and anti-diabetic drugs were excluded from the study. Non consenting students were also excluded from the study.

Informed consent

The students were informed about the ICMR project and requested to be a part of the study population. The students were detailed about the procedure, and after taking their consent, were recruited into the study. A copy of the consent form is sent along with the report.

Institutional ethical committee clearance

The IEC clearance certificate was obtained before starting the research study project. The scanned certificate copy is sent along with the report.

Data collection

The height and weight of the students recruited for the project were measured.

The students' height (without shoes) was measured against the pencil markings on a wall in feet and inches. The measured height was converted into inches, then to centimeters and finally into meters.

The students' weight (without shoes) was measured using a standard weighing scale in kilograms.

The Body Mass Index (BMI) was then calculated using the formula,

BMI = Body Mass (kg)/Height (m^2)

The students were categorized based on their BMI in accordance to the WHO international standard BMI cut-offs.

The blood pressure (systolic and diastolic), blood sugar levels (Fasting blood sugar) and fasting lipid levels were measured for the overweight and obese groups.

The blood pressure for the students was recorded in the sitting position in both the arms and an average was taken. In the event, the blood pressure was more than normal, another recording was made after two to three days, the latest recording being considered as the blood pressure.

The students were asked to give their fasting blood samples for estimation of the blood sugar (FBS) and lipid levels.

The laboratory reports of the same were collected from the students.

Data management and statistical analysis

The BMI, BP recordings, FBS and Lipid levels were entered in to the Microsoft excel worksheet and the same was further used to make the tables, figures and also for the statistical analysis.

The collected information was analyzed using different descriptive and analytic methods with the use of the SPSS version 16 software. Results were expressed in mean and percentages (%). Chi square/Fisher exact test were applied to find out the statistical significance of the qualitative variables. In all the analyses, $P<0.05$ was considered statistically significant.

Subject parameters' evaluation

Blood pressure interpretations were classified as Normal, Prehypertension stage, Hypertension Stage I and Hypertension Stage II, based on the JNC 7 and WHO-ISH guidelines (2003) as follows.

Table 2: Blood pressure classification based on the JNC 7 and WHO-ISH guidelines.

B.P. Classification	Systolic B.P(mm Hg)	Diastolic B.P (mm Hg)

Normal	<120	<80
Prehypertension	120-139	80-89
Hypertension Stage I	140-159	90-99
Hypertension Stage II	≥160	≥100

Based on the blood glucose levels, participants were classified into normal, pre-diabetic and diabetic based on standard recommendations by ADA (American Diabetes Association) and WHO (World Health Organization) as follows.

Table 3: Classification of participant based on the blood glucose levels.

Blood Glucose Levels	AIC (%)	Fasting Plasma Glucose (mg/dl)	Oral Glucose Tolerance Test (mg/dl)
Diabetes	6.5 or above	126 or above	200 or above
Pre-Diabetes	5.7 to 6.4	100 to 125	140 to 199
Normal	About 5	99 or below	139 or below

Blood lipid levels were interpreted into optimal/desirable, higher than optimal, borderline high, high and very high based on NCEP guidelines. (NCEP-ATP III (2004 revision). Grundy. SM et al. Circulation (2004) 11, 227-239 as follows.

Table 4: Blood lipid levels based on NCEP guidelines.

Lipid Levels	Total Cholesterol (mg/dl)	LDL-CH (mg/dl)	HDL-CH (mg/dl)	TGS (mg/dl)
Optimal	<200	<100	>40 (men) >50 (women)	<150
Borderline High	200-239	130-159		150-199
High	≥240	160-189		200-499
Very High		≥190		≥500

The detection of even one abnormality was considered as dyslipidaemia. Here in our study, dyslipidaemia essentially means increased total cholesterol, LDL-cholesterol or triglycerides and even reduced HDL-cholesterol levels.

Students counselling

The students in the overweight and obese groups have been educated regarding the associated risks and counselled for lifestyle modifications like healthy eating habits, physical activity to reduce body weight. The students who were pre-hypertensive, hypertensive, pre-diabetic and dyslipidemia have been appropriately counselled. The pre-hypertensive students have been counselled about the danger of becoming hypertensive if appropriate changes in the lifestyle were not made. The hypertensive students were asked to undergo an echocardiography, fundoscopy, serum creatinine, blood urea and routine urine investigations to rule out end organ damage and determine the chronicity of hypertension. They were also asked to consult the physician and start the appropriate therapeutic intervention.

The pre-diabetics were counselled for their danger in developing type 2 diabetes mellitus and to inculcate appropriate life style changes to prevent the same. The students with dyslipidaemias were counselled to improve their eating habits and increase their physical activity to improve the lipid levels and hence reduce the risk for cardiovascular diseases.

RESULTS

Table 5: Distribution of study subjects according to their BMI.

BMI Category (kg/m^2)	No. of subjects (n=305)	Percentage (%)
< 15	4	1.3
15 to 16	3	0.98
16 to 18.5	48	15.73
18.5 to 25	218	71.47
25 to 30	26	8.52
30 to 35	3	0.98
35 to 40	3	0.98
Over 40	Nil	0

Mean BMI was 21.47 and standard deviation was 3.42.

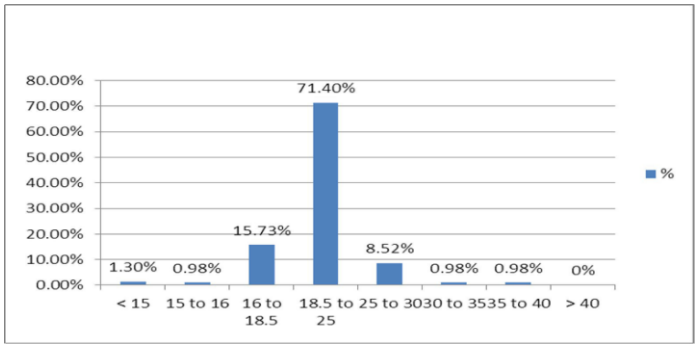

Figure 1: Distribution of study subjects according to their BMI (n=305).

Table 6: Year wise distribution of study subjects.

Year	Number of subjects (n=305)	Percentage (%)
First year	96	31.47
Second year	62	20.32
Third year	76	24.91
Fourth year	40	13.11
Fifth year	31	10.16
Total	305	100

Table 7: Gender-wise distribution of study subjects.

Gender	Number of subjects (n=305)	Percentage (%)
Males	135	44.26
Females	170	55.73
Total	305	100

26 subjects (81.25%) were overweight, 3 (0.98%) were moderately obese and 3 (0.98%) were severely obese (Table 8).

Table 8: Distribution of overweight and obese subjects among study subjects.

BMI Category (kg/m^2)	Number of subjects (n=305)	Percentage (%)
Overweight (25 to 30)	26	8.52
Moderately Obese (30 to 35)	3	0.98
Severely Obese (35 to 40)	3	0.98
Total	32	10.48

Numbers in parenthesis indicates percentage (%). Out of the overweight subjects, 16 (61.5%) were prehypertensives and none were hypertensives. Out of the obese subjects, 4 (66.7%) were hypertensive and none were prehypertensives (Table 9).

Table 9: Distribution of overweight and obese subjects according to the blood pressure status.

BMI Category (kg/m^2)	Blood Pressure			χ^2	p
	Normotensive	Prehypertensive	Hypertensive		
Overweight (n=26)	10(38.5)	16 (61.5)	0 (0)		
Obese (n=6)	2(33.3)	0(0)	4(66.7)	21.060	<0.0001
Total(n=32)	12(37.5)	16(50)	4(12.5)		

Significant association was found between BMI and blood pressure status

Table 10: Distribution of overweight and obese subjects according to their diabetic status.

BMI Category (KG/M^2)	Diabetic Status		X^2	P
	Normal	Prediabetic		
Overweight (n=26)	24 (92.3)	2 (7.7)	0.492	>0.005
Obese (n=6)	6 (100)	0 (0)		
Total	30 (93.8)	2 (6.2)		

Number in parenthesis indicates percentage (%). 2 (7.69%) out of the 26 overweight subjects were in the prediabetic stage and none were diabetic. None from the obese groups were prediabetic or diabetic (Table 10).

There was no statistically significant association between BMI and diabetic status. 22 (84.61%) of the overweight subjects had dyslipidaemias. 3 (100%) of moderately obese subjects and 2 (66.66%) of severely obese subjects had dyslipidaemias. (Table 11). There was no statistically significant association between BMI and lipid profile status.

Table 11: Distribution of overweight and obese subjects with lipid profile status.

BMI Category (KG/M^2)	Lipid Profile Status		X^2	P
	Normal	Dyslipidaemias		
Overweight (n=26)	4 (15.4)	22 (84.61)	0.006	>0.005
Obese (n=6)	1 (16.7)	5 (83.3)		
Total	5(15.6)	27 (84.4)		

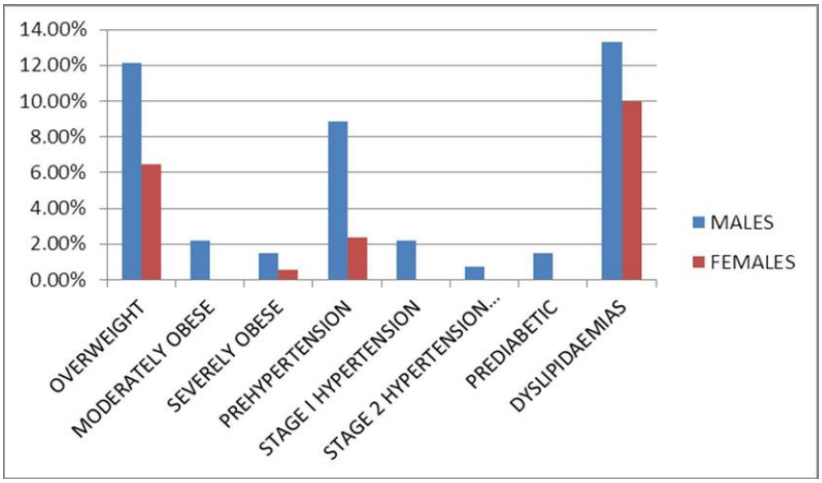

Figure 2: Gender-wise distribution of obesity, hypertension, diabetes and dyslipidaemias.

Table 12: Distribution of overweight and obese groups with specific dyslipidemias.

BMI Category(kg/m^2)	Total Cholesterol	LDL-CH	HDL-CH	TGS
Overweight (n=26)	7 (26.92)	15 (57.69)	11 (42.3)	6 (23.07)
Moderately Obese (n=3)	Nil	2 (66.66)	2 (66.66)	Nil
Severely Obese (n=3)	1 (33.33)	2 (66.66)	1 (33.33)	Nil

Table 13: Gender wise distribution of subjects in the overweight, obesity, hypertensive, diabetic and dyslipidemia categories.

Gender	Over-weight	Mode-rately obese	Severely obese	Pre-hypertension	Hyper-tension stage 1	Hyper-tension stage 2	Pre-diabetic	Diab etic	Dys-lipedim ias
M (n=135)	16 (12.12)	3 (2.22)	2 (1.48)	12 (8.88)	3 (2.22)	1 (0.74)	2 (1.48)	0	18 (13.33)
F (n=170)	11 (6.47)	0	1 (0.58)	4 (2.35)	0	0	0	0	17 (10)
Total	27	3	3	16	3	1	2	0	46

DISCUSSION

Distribution of BMI among the study participants

Out of the 305 students who participated in our study, 55 (18.01%) were in the underweight BMI category (48 were underweight, 3 were severely underweight and 4 were very severely underweight, 218 (71.47%) were normal/healthy weight BMI, 26 (8.52%) were overweight and 6 (1.96%) were obese (3 in moderately obese and 3 in the severely obese) (Table 5, Figure 1).

The distribution of BMI in our study was similar to that reported by Kumar et al.[26] among undergraduate medical students in Kuppam. (8% overweight, 1.5% obese, 20.1% underweight and 70.4% normal). The prevalence of overweight/obese was also similar in another study by Fernandez K et al.[27] among undergraduate medical students in Pune.

A study by Joseph A et al (2006) has reported prevalence of 23.1% among overweight and 1% among obese undergraduate medical students in Trivandrum.[28] A study by Gupta et al (2007) has reported prevalence of 17.5% among overweight and 3.4% among obese undergraduate medical students Kolkata.[29]

The prevalence of overweight/obese students reported was more in a study by Renu Lohitashwa et al.[30] among undergraduate medical students in Belgaum (19.6%

overweight and 24.5% obese). In another study by Mani G, the prevalence reported was 24% amongst the overweight and 9.3% amongst the obese undergraduate medical students from a medical college in Tamilnadu.[31]

The reason for a higher prevalence of overweight and obesity in some of the studies was the revised BMI cut-offs which were used. The BMI cut-off ranges employed were as follows:

1. <18.5 kg/m^2 - Underweight.
2. 18.5 to 22.9 kg/m^2 - Healthy/Normal (18.5 to 24.9 is the WHO criteria for being healthy/normal).
3. 23 to 24.9 kg/m^2 – Overweight (25 to 29.9 is the WHO criteria for being overweight).
4. 25 kg/m^2 and above- Obese (30 and above is the WHO criteria for being obese).

The reason for using these lower BMI cut-offs is probably because of the studies, which have shown that Asians, including Indians have a higher proportion of body fat at the same BMI range than their Caucasian counterparts. There is still a debate as to which BMI cut-offs have to be used. However in our study, we have stuck to the WHO criteria for BMI classification.

In our study, the revised cut-off would have yielded a higher prevalence of overweight and obese individuals. [Overweight - 56 (18.3%) and Obese - 32 (10.49%)].

In our study, the 32 (10.49%) subjects identified in as overweight and obese would be assessed based on their eating habits, physical activity, blood pressure recording, fasting blood sugar, fasting lipid levels, family history of diabetes, hypertension, obesity etc. and appropriately counseled after having assessed the risk factors.

Relationship between BMI and hypertension (Table 9)

In our study, the prevalence of prehypertensives in the overweight subjects was 61.5% (16 out of 26 overweight subjects) and nil in the obese subjects. The prevalence of hypertension (including stage 1 and stage 2) was 66.66% among the obese subjects (4 out of 6 obese subjects) and nil in the overweight subjects. Significant association was found between BMI and blood pressure status in our study. In a study conducted by Das P et al in over 600 undergraduate medical students, overweight and obesity were shown to be positively associated with hypertension.[32]

Relationship between BMI and diabetes (Table 10)

In this study, the prevalence of prediabetes was 7.69% (2 out of 26) in the overweight subjects and nil among the obese subjects. A larger sample size would have been more useful. There was no significant association between BMI and diabetic status in our study.

Relationship between BMI and dyslipidaemias (Table 11 and 12)

The prevalence of dyslipidaemias in study was 84.61% (22 out of 26 overweight subjects) and 83.33% (5 out of 6 obese subjects). There was no significant association between BMI and dyslipidaemias in our study.

The observations in our study show that higher the BMI, more the prevalence of prehypertension, hypertension and dyslipidaemias. This is in accordance to the hypothesis that a higher BMI is associated with more risk for hypertension and dyslipidaemias.

However, pre-diabetes was seen only in the overweight subjects but not in the obese group. This is not in accordance to the hypothesis that a higher BMI is associated with a higher risk of diabetes.

The BRFSS study, the National Heart, Lung and Blood Institute's obesity education initiative, the SHIELD study, the NHANES study, the Framingham heart study, the 15-year follow up in 16,000 men and women study in Eastern Finland have shown that the risk for hypertension, diabetes, dyslipidaemias and cardiovascular diseases increases with increased BMI.[6,8,33-35]

Limitations of the study

The Blood Pressure, FBS and Lipid profile for the normal and the underweight BMI subjects was not done. It could have given a better understanding as to the relationship between BMI and the blood pressure, FBS and lipid levels.

The subjects in the overweight and obese could have been subjected to a questionnaire based study to know about their dietary habits, physical activity habits and familial background of obesity, diseases like hypertension and diabetes

The WHO standard BMI cut-offs were used which has reduced the number of overweight and obese subjects. Waist circumference, waist hip ratios were not considered to categorize study subjects as underweight, healthy, overweight and obese.

Waist circumference, waist hip ratios are considered to be better indicators of visceral (abdominal obesity) than BMI. The study population could have been larger.

Further studies can be done taking into account the waist circumference, waist hip ratio and the BMI and correlating the same with blood pressure, fasting blood sugar and fasting lipid levels using a larger sample size.

CONCLUSION

The prevalence of being overweight and obese among undergraduate medical students is a matter of serious

concern. This reflects on the students' poor dietary habits and inadequate physical activity. A serious approach to reduce body weight through dietary modifications and regular physical activity is the need of the hour.

Difference in prevalence of blood pressure status across the overweight and obese BMI categories was found to be significant. There was no significant association between overweight and obese BMI categories with diabetic and lipid level status. Our study has clearly shown an increased risk of hypertension and dyslipidaemias in the overweight and obese undergraduate medical students.

A metacentric study wherein undergraduates from several medical colleges are recruited and the prevalence of obesity and its correlation with hypertension, diabetes and dyslipidemias is assessed is required. Screening for hypertension, diabetes and dyslipidemias on an annual basis should be made mandatory for undergraduate medical students.

The BMI cut-offs can be taken at a lower range also, to comply with the Asian standards. This would yield more subjects in the overweight and obese categories. Other subject variables like waist circumference, hip waist ratio could also be used to assess the adiposity.

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Ethical approval: The study was approved by Adichunchanagiri Institute of Medical Sciences the Institutional Ethics Committee

REFERENCES

1. Eknoyan G. "Adolphe Quetelet (1796–1874)—the average man and indices of obesity". Nephrol Dial Transplant. 2008;23(1):47–51.
2. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Geneva: World Health Organization; 1995. [3 September 2013]. (WHO Technical Report Series 854). Available at http://www.who.int/childgrowth/publications/physical_status/en/. Accessed 1 August 2015.
3. World Health Organization (2009) Global Database on Body Mass Index: BMI Classification. Available at http://apps.who.int/bmi/index.jsp?introPage=intro_3.html. Accessed 1 August 2015.
4. Kraemer H, Berkowitz RI, Hammer LD. Methodological difficulties in studies of obesity, I: measurement issues. Ann Behav Med. 1990;12:112-8.
5. Must A, Dallal GE, Dietz WH. Reference date for obesity: 85th and 95th percentiles of body mass index (wt. /h2) and triceps skinfold thickness. Am J Clin Nutr. 1991;53:839-46.
6. "Executive Summary". Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. Available at http://www.ncbi.nlm.nih.gov/books/NBK2008/. Accessed 1 August 2015.
7. Carl J Lavie, Richard V Milani, Hector O Ventura. Obesity and Cardiovascular Disease. Risk Factor, Paradox, and Impact of Weight Loss. J Am Coll Cardiol. 2009;53(21):1925-32.
8. Bays HE, Chapman RH, Grandy S, The Shield Investigators' group: The relationship of Body Mass to Diabetes Mellitus, Hypertension and Dyslipidaemia: Comparison of data from two national surveys. Int J Clin Pract. 2007;61(5):737–47.
9. Kitagawa T, Owada M, Urakami T, Yamanchi K: Increased incidence of non-insulin dependent diabetes mellitus among Japanese school children correlates with an increased intake of animal protein and fat. Clin Pediatr. 1998;37:111–6.
10. Dabelea D, Hanson RL, Bennett PH, Roumain J, Knowler WC, Pettitt DJ: Increasing prevalence of type II diabetes in American Indian children. Diabetologia. 1998;41:904–10.
11. Braun B, Zimmerman M, Kretchmer N, Spargo R, Smith R, Gracey M: Risk factors for diabetes and cardiovascular disease in young Australian Aborigines. Diabetes Care 1996;19:472–9.
12. Drake AJ, Smith A, Betts PR, Crowne EC, Shield JP: Type 2 diabetes in obese white children. Arch Dis Child. 2002;86:207–8.
13. Ramachandran A, Snehalatha C, Satyavani K, Sivasankari S, Vijay V: Type 2 diabetes in Asian-Indian urban children. Diabetes Care. 2003;26:1022–5.
14. Pihoker C, Scott CR, Lensing SY, Cradock MM, Smith J: Non-insulin dependent diabetes mellitus in African-American youths of Arkansas. Clin Pediatr (Phila). 1998;37:97–102.
15. American Diabetes Association: Type 2 diabetes in children and adolescents. Diabetes Care. 2000;23:381–9.

16. Alfredo Halpern, Marcio C Mancini, Maria Eliane C Magalhães, Mauro Fisberg, Rosana Radominski, Marcelo C Bertolami, et al.Metabolic syndrome, Dyslipidemia, Hypertension and Type 2 Diabetes Mellitus in youth: from diagnosis to treatment. Diabetol Metab Syndr. 2010;2:55.
17. Elaine M Urbina, Philip R Khoury, Connie McCoy, Stephen R Daniels, Thomas R Kimball, Lawrence M Dolan. Cardiac and Vascular Consequences of Pre-hypertension in Youth. J Clin Hypertens (Greenwich). 2001;13(5):332-42.
18. Flegal JN, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999–2000. JAMA. 2002;288:1723-7.
19. Lavie CJ, Milani RV. Obesity and cardiovascular disease: the Hippocrates paradox? J Am Coll Cardiol. 2003;42:677-9.
20. Manson JE, Bassuk SS. Obesity in the United States: a fresh look at its high toll. JAMA. 2003;289:229- 30.
21. Poirier P, Giles TD, Bray GA. Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss: an update of the 1997 American Heart Association scientific statement on obesity and heart disease from the obesity committee of the council on nutrition, physical activity, and metabolism. Circulation. 2006;113:898-918.
22. Klein S, Burke LE, Bray GA. Clinical implications of obesity with specific focus on cardiovascular disease: a statement for professionals from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism: endorsed by the American College of Cardiology Foundation. Circulation. 2004;110:2952-67.
23. Litwin SE. Which measures of obesity best predict cardiovascular risk? J Am Coll Cardiol. 2008;52:616-9.
24. Ford ES, Capewell S. Coronary heart disease mortality among young adults in the U.S. from 1980 through 2002: concealed levelling of mortality rates. J Am Coll Cardiol. 2007;50:2128-32.
25. Garrow JS. Obesity and related diseases. London. Churchill Livingstone 1988:1-16. Available at http://whqlibdoc.who.int/trs/WHO_TRS_894 (part1) pdf. Accessed on 2 August 2015.
26. Kumar CA, Revannasiddaiah N, Gopi A, Nanjundappa VH. A cross-sectional study on the dietary factors and their association with body mass index among undergraduate medical students in a medical college. Int J Res Health Sci [Internet] 2014 Apr 30; 2(2):591-8. Available at http://www.ijrhs.com/issues.php?val=Volume2&iss=Issue2. Accessed on 2 Aug 2015.
27. Fernandez K, Singru SA, Kshirsagar M, Pathan Y. Study regarding overweight/obesity among medical students of a teaching hospital in Pune, India. Med DY Patil Univ [serial online] 2014 [cited 2015 Aug 2];7:279-283. Available at http://www.mjdrdypu.org/article.asp?issn=0975-2870;year=2014;volume=7;issue=3;spage=279;epage=283;aulast=Fernandez. Accessed on 2 Aug 2015.
28. Joseph A, Mohan AS, Arathy R, Barma AD, Varghese S. Prevalence of obesity among students in Government Medical College, Thiruvananthapuram. Available at http://www.commedtvm.org/ug_research/ug_research_undated/ug_research_04.html. Accessed on 2 August 2015.
29. Gupta S, Guha RT, Saha I. Overweight, Obesity and Influence of Stress on Body Weight among Undergraduate Medical Students. IJCM. 2009;34(3):255-7.
30. Renu Lohitashwa and Parwati Patil. A cross sectional study of relationship of obesity indices with blood pressure and blood glucose level in young adult medical students. International Journal of Basic Medical Sciences. 2012;3(4):102-7.
31. Mani G. Assessment of body mass index and its associated nutritional factors among undergraduate medical students in Tamil Nadu, India: A cross sectional study. J Pioneer Med Sci. 2014;4(3):137-42.
32. Das P, Basu M, Chowdhury K, Mallik S, Dhar G, Biswas A. Observational assessment and correlates to blood pressure of future physicians of Bengal. Niger J Clin Pract. 2013;16:433-8.
33. Ali H Mokdad, Earl S Ford, Barbara A Bowman, William H Dietz, Frank Vinicor, Virginia S Bales, et al. Obesity-Related Health Risk Factors 2001. JAMA. 2003;289:76-9.
34. Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26 year follow-up of participants in the Framingham Heart Study. Circulation. 1983;67:968-77.
35. Manson JE, Colditz GA, Stamper MJ, Willett WC, Rosner B, Monson RR, et al. A prospective study of obesity and risk of coronary heart disease in women. New England Journal of Medicine. 1990;322:882-9.

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