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Demographic Variations Influence Obesity in a Semi-urban Cohort of Tamil Nadu, South India

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ABSTRACT This case control study identified certain definite factors influencing obesity and dyslipidemia in semi- urban subjects aged between 20 and 44 years of age. Obese cases (n= 177,) and controls (*n* = 166) were recruited by random sampling method and categorised into three age groups. The mean BMI, WHR and TGL were highest in obese subjects aged between 37 to 44 years. The mean TC levels (181.43 mg/dl) and mean TGL levels (180.29 mg/dl) were higher in vegetarians than in non- vegetarians. Further, the mean TGL levels (183.86 mg/dl) were highest in subjects who used hydrogenated vegetable oil as a cooking medium. TGL was derived as the most significant variable for dyslipidemia in the study cohort ($r^2 = 0.838$,) with WHR, alcoholism, smoking, TC, LDL, HDL, FBG, and LDL/ HDL ratio as predictor variables.

INTRODUCTION

Excess weight has been identified as an important risk factor for many diseases including hypertension, diabetes, cardiovascular disease and rheumatologic problems (Kaufman et al. 1996; Okusun et al. 1998). The World Health Organization (WHO) had declared that obesity is an epidemic on a global scale posing a major threat to human health and well- being (WHO 2004). In India, obesity is emerging as an important health problem particularly in urban areas, paradoxically co-existing with under- nutrition. A large number of adult urban Indians (30 to 65%) are either overweight or obese or have abdominal obesity. In India, the rising rates of obesity are associated with the transition from rural to urban lifestyle. Recent epidemiological trends in obesity indicate that the primary cause of the obesity crisis lies in environmental and behavioural changes (Misra and Khurana 2008). Georges et al. (2005) suggested a larger role for socio- cultural factors in the patterning of body fat distribution. The interaction of environmental factors, physical inactivity, over- eating and socio- economic conditions affects an individual's risk for obesity (Hill and Peters 1998). Fast paced lifestyle, rapidly changing food habits and socio-economic transition is widely prevalent. Most remarkably, the obesity pandemic is penetrating even the poorest nations in the world, first amongst the urban middle aged adults, but increasingly affecting semi-urban and rural areas and younger age groups (Nishida and Mucavele 2005). Thus in this cohort study, the researchers investigated the concomitant factors that influence obesity and dyslipidemia in adults aged between 20 to 44 years in a semi urban cohort of Coimbatore, Tamil Nadu.

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METHODOLOGY

The main objective of this study was to elucidate certain definite factors that influence obesity and dyslipidemia in young and middle aged subjects who shift from their rural native inhabitations to urban areas in for economic benefits. This case control study was approved by the human ethics committee of a multi-speciality hospital in Coimbatore. The study was advertised as "hand outs" and volunteers for the study were invited. A detailed Questionnaire based interview was conducted in obese subjects who had migrated from rural to urban areas of Coimbatore, (*n* = 625). Subjects between 20 to 44 years of age were specifically chosen for a detailed study as there is a gradual but distinct change in the lifestyle and dietary pattern, in the productive years of life, which leads to weight gain and obesity. Random sampling method was adopted to recruit above one half of the initial cohort for clinical study (that is, total *n* = 343, obese subjects *n* = 177, non-obese controls *n* = 166,). The subjects for the study were first examined by a physician and a detailed medical history was taken to ensure that the subjects were healthy over the last one year during the period of the study. The demographic status of the subjects was also cross checked with the details on the electoral card and an informed written consent was obtained. A subject was defined as a smoker or alcoholic if a history of smoking or alcoholism was recorded for at least one year during the period of study. The study subjects were recruited from the same geographic location and matched for gender and age groups. Further, they were classified into three different age groups and a self reported, dietary recall questionnaire was used to analyse the dietary intake over a period of one week during the study. The cases and controls for the study were determined in accordance to the Asia pacific guidelines for defining obesity.

Clinical Assessment

Cases and control subjects who were enrolled for the clinical study were instructed to report to the clinic between 7:00 and 9:00 am, in fasting state and in light clothing. Further they were instructed to avoid urine prior to clinical assessment. Male and female nurses recorded anthropometric measurements for the subjects of respective genders. The weight was recorded to the nearest 0.1 kg using a weighing machine calibrated for accuracy. The height was recorded to the nearest 0.1 cm. stadiometer fixed to the wall. Waist circumference (WC) was measured using a non- stretchable measuring tape with the participant standing erect, abdomen relaxed, arms at the side and feet together with weight divided equally over both legs. Participants were told to breathe normally and to breathe out gently at the time of measurement. Hip circumference was measured at the level of the maximal protrusion of the gluteal muscles. It was expressed as centimetres (cms). Waist hip ratio (WHR) was calculated by the formula waist (cms) / Hip (cms). Body mass Index (BMI) was calculated by the formula - Weight (kg) / Height (m^2) and expressed as kg/m^2 (Aekplakorn et al. 2006).

Metabolic Factors

Five ml of venous blood sample from each subject was obtained for biochemical analyses obtained by vein puncture of the median cubital vein in the right hand. The blood samples were stored on ice and transported to the laboratory immediately. Serum was obtained by centrifugation of the blood samples, in a centrifuge at 1600 rpm for 20 minutes at 4°C and an aliquot of serum was tested for total cholesterol (TC) and Triglycerides (TGL) using a semi automated analyser using commercial reagents. Total cholesterol was measured by Cholesterol oxidase - peroxidase (CHOD – POD) method. Fasting plasma glucose (FPG) was measured by Glucose oxidase – Peroxidase method (GOP–POD). High density lipoprotein cholesterol (HDL-C) was determined by precipitation with phosphotungstic acid and magnesium chloride as per the instructions of the manufacturer. Low density lipoprotein cholesterol (LDL-C) was estimated by Friedwald formula (William et al. 1972). Very low density lipoprotein cholesterol was abbreviated as VLDL-C. All biochemical values were expressed in milligrams per decilitre (mg/dl).

Clinical Standards

Asian Indians have higher percentage body fat, abdominal obesity at lower or similar BMI levels as compared to white Caucasians (Misra and Khurana 2008). Therefore obesity in the study cohort was defined in accordance to the Asia Pacific guidelines wherein obesity is defined as a BMI of more than 25 kg/m^2, pre-obese as BMI between 23-24.9 kg/m^2 and those with BMI of 18.5-23 kg/ m^2 were considered as normal range. Abdominal obesity in men and women was defined as a waist circumference of 90 cms and 80 cms respectively. High WHR in males is defined as > 0.95 and > 0.80 in females (Asia Pacific Report 2000). Dyslipidemia was defined by the criteria formulated by the National cholesterol education program, Adult treatment panel III (NCEP–ATP III Report 2002). Dysglycemia was defined in accordance to IDF definition (IDF Report 2006).

Data Analysis

The data were entered into an Excel spread sheet and double checked for errors. Students *'t'* test and one way ANOVA were applied for comparison of mean difference of continuous variables among cases and controls. The correlation between anthropometric factors and biochemical factors was tested by Pearson's two tailed correlation test. The significant factors predictive of BMI and TGL in the study cohort were determined by multiple linear regression analysis. All statistical analyses were performed by SPSS (version 11, Chicago: SPSS, Inc.).

RESULTS

The mean BMI among obese cases (*n*=177) was 29.67±3.01 kg /m^2 (Table 1). The mean BMI of obese males (*n* = 89) was comparatively less than in obese females (*n*= 88) (Table 2). The mean waist to hip ratio (WHR) was higher in obese males (1.01) than in obese female subjects (0.87) indicating abdominal obesity in males. However, the mean fasting blood plasma glucose levels (FPG) was higher in obese females (115.99 mg/dl) indicating hyperglycaemia. In obese cases the mean triglyceride levels and mean LDL levels were comparatively higher than controls, indicating a higher risk for cardiovascular diseases. The mean BMI among non obese controls (*n* = 166) was 23.31±4.0 kg/m^2 and the mean WHR in non obese males and females was 0.91 and 0.84 respectively (Table 1).

Table 1: Clinical profile of cases and controls

Clinical variable	*Cases (n=177)*	*Controls (n=166)*	*P value*
BMI (kg/m2)	29.67± 3.01	23.31 ± 4.0	0.00*
WHR	0.94± 0.08	0.88 ± 0.22	NS
FBG (mg/dl)	107.46±18.84	104.12 ±10.66	0.001*
TC (mg/dl)	180.21±23.16	168.72 ±36.26	0.000*
TGL (mg/dl)	177.71±10.53	125.71 ± 5.58	0.000*
HDL (mg/dl)	34.74±11.77	47.79 ±14.56	0.000*
LDL (mg/dl)	136.04±25.30	94.99 ±26.34	0.000*
VLDL (mg/dl)	27.32±19.00	25.41 ±15.74	NS
LDL/HDL Ratio	4.72± 1.27	1.954± 0.55	0.001*

Table 2: Clinical profile of cases and controls based on gender

Clinical variables	*Male cases*	*Male controls*	*Female cases*	*Female controls*
BMI (kg/m2)	31.1	23.42	29.23	23.15
WHR	1.01	0.9125	0.87	0.8434
FBG (mg/dl)	99.39	105.49	115.99	101.93
TC (mg/dl)	169.47	115.99	187.18	167.52
TGL (mg/dl)	187.03	130.38	171.68	118.26
HDL (mg/dl)	34.74	47.79	31.98	52.91
LDL (mg/dl)	143.72	97.57	129.65	90.88
VLDL (mg/dl)	24.23	26.52	24.98	23.63
LDL/HDL ratio	4.54	2.09	4.76	1.72

Factors Influencing Anthropometry and Serum Lipid Profile

Among various demographic and life style factors, this study identified smoking, alcoholism, dietary habits and edible oil used in cooking as significant factors influencing obesity and dyslipidemia in the semi urban subjects of Coimbatore.

1. Gender and Age Groups*:* The mean BMI among obese males (31.10±3.79 kg/m$^{2)}$, mean WHR (1.01) mean TGL values (187.03 mg/dl), mean LDL values (143.72 mg/dl) were higher than in obese females. In non obese controls, the mean TC levels were nearly similar in males and females. The mean TGL levels differed considerably between males and females considerably with a higher mean TGL level in males. BMI, WHR, FBG and TC were significant factors in male and female cases (P < 0.05) and thus serve as an ideal biochemical factors in the study cohort. The study subjects were categorised into three age groups for identification of age specific factors influencing body weight. Among cases BMI, TGL and LDL/HDL ratio were identified as statistically significant factors in all the three age groups. In the control groups, the significant factors influencing BMI were TC, TGL, HDL, LDL and VLDL (P < 0.05). Among age groups, highest mean BMI (32.55 kg/m$^{2)}$ was recorded in obese subjects aged between 37–44 years. The mean LDL values (140.88 mg/dl) were highest in obese subjects aged between 20 - 28 years. BMI, TGL and LDL/HDL ratio were significant factors among cases (Table 3). In controls, the mean TGL level (179.31 mg/dl) was observed in subjects aged between 37–44 years (Table 3). TC, TGL, HDL, LDL and VLDL were significant factors in controls (Tables 2 and 3).

2. Smoking and Alcoholism: Smoking and alcoholism are the two major risk factors for cardiovascular diseases in obese subjects. Only males were smokers and alcoholics in the study cohort. Alcoholism had a significant effect (P≤ 0.05) on BMI, WHR, FBG, TC and LDL. The mean BMI (31.81 kg/m^2) was higher in alcoholics than non alcoholics (29.24 kg/m$^{2)}$.The mean BMI and the HDL values were nearly similar among smokers and non smokers. LDL was derived as a significant variable among non smoking obese men (Table 4a). Among non obese men, the mean BMI (23.58 kg/m$^{2)}$) and

Table 3: Clinical profile of obese subjects across age groups

Clinical variable	*20 - 28 years Cases*	*20 - 28 years Controls*	*29 - 36 years Cases*	*29 - 36 years Controls*	*37 - 44 years Cases*	*37 - 44 years Controls*
BMI (kg/m^2)	28.21	22.59	28.78	23.47	32.55	23.87
WHR	0.948	0.89	0.914	0.86	0.964	0.88
FBG (mg/dl)	106.53	103.16	111.61	103.05	106.04	104.44
TC(mg/dl)	183.04	156.7	178.57	168.78	177.73	181.88
TGL(mg/dl)	162.84	101.88	180.72	123.02	191.34	179.31
HDL(mg/dl)	33.77	48.14	32.72	51.18	33.45	48.16
LDL(mg/dl)	140.88	89.21	137.96	93.6	132.76	99.09
VLDL(mg/dl)	26.12	20.56	24.48	24.85	23.5	36.16
LDL/HDL Ratio	4.69	1.87	5.02	1.86	4.39	2.13

WHR was comparatively higher in alcoholics than in non alcoholic men indicating that smoking and alcoholism. Further, LDL/HDL ratio was derived as significant variable ($P < 0.05$) among smokers (Mean BMI 23.05 kg/m$^{2)}$) and non smokers (Mean BMI = 22.04 kg/m^2 (Table 4b).

Table 4a: Influence of smoking and alcoholism on BMI, WHR and clinical profile in cases

Clinical variable	*Alco-holics*	*Non-alco-holics*	*Smokers*	*Non-smokers*
BMI (kg/m^2)	31.81	29.24	30.21	30.16
WHR	1.01	0.9	1.02	0.92
FBG (mg/dl)	100.38	111.76	100.79	109.27
TC(mg/dl)	171.48	184.28	177.29	180.22
TGL(mg/dl)	184.59	176.46	189.44	177.01
HDL(mg/dl)	34.8	32.55	33.1	33.43
LDL(mg/dl)	146.41	131.24	137.71	136.49
VLDL(mg/dl)	23.24	25.37	25.88	24.3
LDL/HDL Ratio	4.55	4.71	4.65	4.65

Table 4b: Influence of smoking and alcoholism on BMI, WHR and clinical profile in controls

Clinical variable	*Alco-holics*	*Non-alco-holics*	*Smokers*	*Non-smokers*
BMI (kg/m^2)	23.58	21.64	23.05	22.04
WHR	0.88	0.81	0.88	0.85
FBG (mg/dl)	106.83	100	104.95	105.45
TC(mg/dl)	174.29	169	168.87	170.00
TGL(mg/dl)	156.94	140.75	116.52	117.09
HDL(mg/dl)	48.28	137.9	52.58	49.41
LDL(mg/dl)	94.62	92.42	102.27	96.55
VLDL(mg/dl)	25.41	27.58	24.70	27.14
LDL/HDL ratio	1.97	2.58	2.26	2.03

3. Dietary Pattern: In this study cohort, subjects were categorized mainly as vegetarians and non vegetarians. 142 obese subjects (79 %) were non vegetarians who consumed either chicken, mutton, fish or beef, at least once in a week. The mean BMI among non- vegetarians (30.29 kg/m$^{2)}$) was comparatively higher than the mean BMI (29.40 kg/m$^{2)}$ of vegetarians. The mean TC levels (181.43 mg/dl) and mean TGL levels (180.29 mg/dl) were higher in vegetarians than in non- vegetarians (Table 5). The mean LDL/HDL ratio (4.73) was higher in non vegetarians than in vegetarians (4.35). FBG was derived as a significant variable influencing BMI among vegetarians and non vegetarian, obese cases ($P < 0.05$) but TC and LDL were derived as significant factors in controls. The mean FBG level (103.77 mg/dl) was higher among non vegetarians than vegetarians (Table 5).

Table 5: Dietary habits and its influence on clinical profile in cases and controls

Clinical variable	*Non-vege-tarians (Cases)*	*Non-vege-tarians (Controls)*	*Vege-tarians (Cases)*	*Vege-tarians (Controls)*
BMI (kg/m^2)	30.36	23.7	28.4	23.04
WHR	0.94	0.875	0.93	0.88
FBG (mg/dl)	109.1	103.77	101.6	97.9
TC(mg/dl)	179.22	169.68	181.43	176.02
TGL(mg/dl)	179.18	128	180.29	101.02
HDL(mg/dl)	32.36	49.02	37.45	49
LDL(mg/dl)	135.65	101.6	141.09	95.44
VLDL(mg/dl)	24.23	24.02	26.11	30.05
LDL/HDL Ratio	4.73	2.07	4.35	1.94

4. Edible Oils: Four main kinds of edible oils namely sunflower oil, groundnut oil, coconut oil and hydrogenated vegetable oil (*Vanaspathi*) was used in cooking. Coconut oil and hydrogenated vegetable oils were used by people of low socio-economic strata. The mean TGL levels (183.86 mg/dl) was highest in obese subjects who used hydrogenated vegetable oil for cooking, The lowest mean TGL levels were recorded in subjects who used sunflower oil as a cooking medium (Table 6a and 6b). On the contrary, the mean LDL levels were highest in obese subjects who used sunflower oil as edible oil. In non obese controls the LDL levels were highest in those who used hydrogenated oil as cooking medium.

Table 6a: Influence of edible oil used on biochemical variables in cases

Clinical variable	*Sun flower oil*	*Ground nut oil*	*Coconut oil*	*Hydro-genated vegetable oil*
BMI (Kg/m^2)	29.93	29.98	30.99	30.49
WHR	0.95	0.95	0.91	0.94
FBG (mg/dl)	106	106.72	108.73	114.14
TC (mg/dl)	179.2	178.72	179.73	183.81
TGL (mg/dl)	177.55	179.62	179.65	183.86
HDL (mg/dl)	33.92	35.29	29.69	30.01
LDL (mg/dl)	139.65	137.91	130.15	132.38
VLDL (mg/dl)	25.97	24.68	22.96	22.33
LDL/HDL ratio	4.6	4.62	4.82	4.65

Table 6b: Influence of edible oil used on biochemical variables in controls

Clinical variable	*Sun-flower oil*	*Ground-nut oil*	*Coco-nut oil*	*Hydro-genated vegetable oil*
BMI (kg/m^2)	23.99	23.09	25.28	24.87
FBG (mg/dl)	106.61	102	109	110.33
TC (mg/dl)	171.36	168.49	181.25	161.63
TGL (mg/dl)	135.31	121.02	114.5	173.3
HDL (mg/dl)	49.17	50.02	63.3	47.8
LDL (mg/dl)	96.65	94.8	79.17	101.4
VLDL (mg/dl)	24.47	24.47	16.55	34.66
LDL/HDL ratio	2.04	1.93	1.65	1.68

Data is expressed as Mean Value for each variable.

Correlation between Anthropometric and Biochemical Factors

Pearson's two tailed coefficient test was applied to test the correlation between clinical factors and anthropometric factors. Among obese cases a positive correlation was observed between BMI and WHR and between TC and FPG. TGL correlated positively with WHR and serves as a clinical feature in abdominal obesity. LDL is also positively correlated to WHR. ($P > 0.05$) (2 tailed) (Table 7a). Among controls, positive correlation was observed between BMI and FBG but not with LDL. Further BMI correlated significantly with WHR, TC, TGL, VLDL and LDL/HDL (Table 7b). This indicates that BMI and WHR influence the lipid profile in both cases and controls.

Predictor Variable for BMI and Dyslipidemia: Multiple linear regression analysis was applied to identify the most significant predictive factors for BMI in the study cohort. The factors namely age group of subject, meat consumption along with clinical factors namely WHR, TGL, and LDL / HDL ratio influence BMI and act as predictive factors in the study cohort. The regression coefficient *(r^2)* value for BMI was 0.540 (Table 8a). This implies that the clinical variables namely WHR, TGL, and LDL / HDL ratio influence BMI upto 54 percent in the study subjects of Coimbatore. TGL was derived as the most significant variable for dyslipidemia in the study cohort. The predictor factors for TGL were WHR, alcoholism, smoking, TC, LDL, HDL, FBG, and LDL/ HDL ratio with a regression coefficient (r^2) = 0.838 (Table 8b). This implies that the factors namely WHR, alcoholism, smoking, TC, LDL, HDL, FBG, and LDL/ HDL ratio influence serum triglyceride levels upto 83 percent in the semiurban subjects of Coimbatore.

DISCUSSION

The present study recorded obesity across different vulnerable age groups. Higher fasting

Table 7(a): Correlation matrix across clinical variables in cases with BMI as dependent variable

		BMI	*WHR*	*FBG*	*TC*	*TGL*	*HDL*	*LDL*	*VLDL*	*LDL / HDL ratio*
BMI	Pearson Correlation									
WHR	Pearson Correlation	**0.312***								
FBG (mg/dl)	Pearson Correlation	-.070	**-0.314***							
TC	Pearson Correlation	-.040	-.218	**445***						
TGL	Pearson Correlation	.115	0.**241***	0.105	.038					
HDL	Pearson Correlation	-.033	-0.039	**-.158***	-.021	.010				
LDL	Pearson Correlation	-.030	0.**415***	-0.058	.014	0.**294***	-0.047			
VLDL	Pearson Correlation	**-0.212***	-0.026	-.045	**0.174***	0.120	0.147	.052		
LDL/HDL ratio	Pearson Correlation	-0.103	0.125	**0.210***	0.054	0.116	**-0.515***	**0.423***	-0.109	

* Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at 0.01 level (2 tailed)

Table 7(b):Correlation matrix across clinical variables in controls, with BMI as dependent variable

		BMI	*WHR*	*FBG mg/dl*	*TC*	*TGL*	*HDL*	*LDL*	*VLDL*	*LDL/ HDL ratio*
BMI	Pearson Correlation									
WHR	Pearson Correlation	**0.744****								
FBG	Pearson Correlation	**0.366****	**-.210***							
TC	Pearson Correlation	**0.161***	-0.198	**0.206****						
TGL	Pearson Correlation	**0.187***	0.120	**0.187****	**0.568****					
HDL	Pearson Correlation	0.37	-0.032	**NS**	**0.259****	**-2.63****				
LDL	Pearson Correlation	0.46	**0.359***	NS	0.837	**0.210****	**0.212****			
VLDL	Pearson Correlation	**0.167***	-0.022	**0.156***	**0.551****	**0.993****	**-02.64****	**0.223****		
LDL/HDL ratio	Pearson Correlation	**0.192***	0.118	**0.296****	**0.595****	**0.366****	**-02.67****	**0.684****	**0.371****	

*Correlation is significant at 0.05 level (2-tailed)
**Correlation is significant at 0.01 level (2 tailed)

Table 8a: Coefficient values for regression model with BMI as dependent variable

Clinical variables	*Unstandardized coefficient beta value*	*Standard error*	*Standardized coefficients beta value*	*t- value*	*Significance*
FBG	0.027	0.012	0.092	2.252	0.025
TC	0.002	0.008	0.010	0.199	0.842
TGL	-0.002	0.006	-0.036	-0.405	0.686
HDL	0.011	0.004	0.166	3.012	0.003
LDL	-0.006	0.010	-0.039	-0.583	0.560
LDL/HDL	0.015	0.219	0.005	0.068	0.946
WHR	5.326	1.080	0.186	4.932	0.000

Dependent variable: BMI
Predictor variables: WHR, TC, FBG, HDL, LDL, LDL/HDL ratio, TGL and alcoholism
Regression coefficient value (r^2) = 0.540.

Table 8b: Coefficient values for regression model with TGL as dependent variable

Clinical variables	*Unstandardized coefficient beta value*	*Standard error*	*Standardized coefficients beta value*	*t value*	*Significance*
FBG	0.227	0.110	0.052	2.062	0.040
BMI	-0.184	0.532	-0.012	-0.345	0.730
TC	0.047	0.075	0.020	0.635	0.526
HDL	-0.073	0.034	-0.074	-2.170	0.031
LDL	0.231	0.092	0.105	2.520	0.012
LDL/HDL	-0.430	1.968	-0.010	-0.218	0.827
WHR	5.330	10.257	0.013	0.520	0.604

Dependent Variable: TGL
Predictor variables: Meat intake, TC, WHR, FBG, HDL, LDL, LDL/ HDL ratio.
Regression coefficient value (r^2) = 0.838

blood glucose levels were observed in females than males. The mean BMI and WHR were higher in males than in females. Dietary preferences, consumption of alcohol and habitual smoking had a greater influence on BMI among males. Ghosh et al. (2003) reported positive associations of almost all central obesity measures with metabolic factors in middle aged Bengali men in Eastern part of India. In the present study, the mean triglyceride levels were higher for males with more variations than females similar to the observation of Misra et al. (2001a), in an urban slum population of Delhi in Northern India. In this study the researchers observed that the mean TGL levels were significant in obese cases of all age groups but the mean total cholesterol levels (187.03 mg/dl) was highest in obese women in the age group of 37 - 44 years than men, indicating a borderline high risk as per the ATP III guidelines (NCEP ATP III

Report 2002). A similar study by Varghese et al. (2008), reported 41.7 % obesity in subjects of the age group 40-49 years and 41.9 % in the age group of 50-59 years in a population of Kerala in Southern India.

A major proportion of obese subjects in the present study (n = 142) preferred a non-vegetarian diet than a vegetarian diet owing to its ease in cooking and appetizing appeal. This is similar to the observations in a study from Delhi by Misra et al. (2001b) wherein a preponderance of non vegetarianism and significant dyslipidemia was observed. A high dietary intake of fat, implicated in the development of obesity and hyperglycaemia, has been reported in Asian Indians (Cox et al. 1995). Vegetable oils are the major source of visible fats contributing to more than half of the daily fat calories (Radhika et al. 2010). Indian households both in urban and rural areas continue to use single oil for cooking (Rogers et al. 1998). In the present study, the mean TGL levels were highest among subjects who used hydrogenated vegetable oils containing almost 53% of Trans- fatty acids (TFA). Since this oil is cheaper than other cooking oils and commonly available even in rural areas, it is widely consumed by individuals belonging to middle and low socio-economic strata. In urban slum dwellers belonging to low SES in New Delhi, trans- fatty acids, particularly in men, reached above 1% of the energy intake mostly due to the use of hydrogenated vegetable oil in cooking (Misra et al. 2001b). Further in this study, the researchers observed higher mean TGL levels among obese subjects who used coconut oil as a cooking medium. Certain studies have demonstrated that consumption of coconut oil containing 90% saturated fats might result in undesirable lipid profile changes compared to safflower oil (Cox et al. 1995) and soyabean fat (Mendis and Kumarasunderam 1998). Sabitha et al. (2009) observed elevated serum TGL levels in subjects who used coconut oil than those who used sunflower oil as a cooking medium similar to the observations in the present study.

In this study the mean LDL–C levels was highest among obese male subjects which is a potential indicator for atherosclerotic vascular disease in the later years. Moreover, elevated serum LDL-C level is associated with an increased risk of Ischemic heart disease independent of the potential effects of diabetes or hypertension (Lamarche et al. 1997; Crouse 1998). Of particular concern is the elevated levels of LDL-C in obese men aged 20 - 28 years indicating a borderline to high risk as per the NCEP ATP III guidelines. This is a potential risk factor for the development of metabolic syndrome in the later years. High intake of saturated fats and trans-fatty acid rich food may be the key factor for the alarmingly elevated levels of LDL in young men as trans-fatty acids raise levels of LDL –C and lower levels of HDL-C at relatively high oral intakes (Lamarche et al. 1997). Linear regression model derived WHR, HDL, FBG, LDL, LDL/HDL ratio as predictor factors influencing TGL levels of this study cohort. The regression coefficient obtained was 0.838 indicating that TGL levels are influenced upto 83 percent by the above mentioned factors in this study cohort. The predictive factors influencing BMI upto 54 percent, in the study cohort were FBG, HDL, LDL, LDL/ HDL ratio similar to the observations of Misra et al. (2001a). As against the latest WHR cut off for Asian Indians (Misra et al. 2009), the mean WHR for men and women in the obese cohort was 1.01 and 0.877 respectively. Obese subjects in the age group of 37 to 44 years had higher waist hip ratios indicating the need for appropriate medical interventions as this group is susceptible to metabolic syndrome and Type II diabetes. The INTERHEART study showed that waist to hip ratio was a much better predictor of CVD events than BMI (Yusuf et al. 2004). In an extensive cohort study by Gupta et al. (2007), a positive correlation between BMI, WC and WHR with fasting glucose, LDL cholesterol and systolic and diastolic blood pressure was observed whereas a negative correlation was observed with physical activity and HDL cholesterol in both men and women.

In the present study only male subjects were smokers and alcoholics. Dyslipidemia in men was influenced by social factors namely alcoholism and smoking. However, in this study we could not report the type of alcohol consumed by men due to factors of confidentiality. Smoking is a potent risk factor as cigarette smoke derived oxidants may affect many obesity related hormones such as leptin, adiponectin and resistin that are produced by adipose tissue. Chemokines released as a result of oxidative stress may lead to dysregulation of adipocytokines and ultimately metabolic syndrome. The mean BMI and WHR were higher among alcoholic men than non alcoholics. A similar observation was recorded by Mataix et al. (2005) in which obese smokers had a larger mean waist circumference and WHR than obese non- smokers. Moreover, obese smokers had lower levels of HDL cholesterol as observed in the present study. Over a ten- year prospective study, Vadstrup et al. (2003) observed that a high alcohol intake was associated with increased waist circumference after ten years in both men and women. This is similar to the observations of the present study in wherein a higher BMI and WHR was observed in alcoholic men. Alcoholic beverages are energy dense and may not be substituting for food, but rather add to the total daily energy intake (Vadstrup et al. 2003). Inhibition of fat oxidation might occur as a consequence of the antilipolytic properties of metabolites from alcohol degradation. These features could potentially promote fat storage and hence promote an increased risk of developing obesity (Crouse et al. 1968).In accordance to the guidelines of consensus statement for Asian Indians (Misra et al. 2009) which has stated a BMI cut-off of 23 kg/ m^2 as ideal BMI, an alarming picture exists on the health status of the subjects in our study. India is undergoing rapid nutritional transition resulting in excess consumption of calories, saturated fats, trans- fatty acids, simple sugars, salt and low intake of dietary fibre. A hectic, sedentary lifestyle and the easy availability of convenience foods have led to irregular meals and frequent snacking on energy dense foods. This nutrition transition has the potential to cause obesity and other diet- related noncommunicable diseases in the urban, semi- urban and rural areas. Obesity is a major predisposing factor for diabetes. Over the past three decades, diabetes has become a major cause for morbidity and mortality affecting the youth and middle aged. Obesity accounts for more than 90 % of them. The need of the hour is therefore to establish well planned longitudinal and multicentric interventional programmes, stressing the importance of ideal body weight management, healthy dietary pattern and physical activity regimen, targeted towards the study cohort and other risky populations of India (Misra et al. 2009). It is pertinent for the study cohort to adhere strictly to the recent consensus dietary guidelines (Misra et al. 2011).

CONCLUSION

Obesity and dyslipidemia in the semi- urban study cohort is influenced by four main factors namely Dietary pattern, Smoking, Alcoholism and Kind of edible oil used in cooking. Obesity and dyslipidemia in subjects aged between 20 to 44 years can be attributed to lack of awareness on healthy eating and also to the rural to urban changes in eating habits. This demands appropriate interventions on healthy lifestyle and dietary changes in addition to increase in physical activity.

RECOMMENDATIONS

A large scale intervention program on the importance of healthy lifestyle, food habit, and physical activity needs to be advocated in the rural population. An effective approach will be to commence intervention programs on abdominal obesity and generalised obesity, for subjects from 20 years of age as this is the most vulnerable to develop obesity and its related co morbidities in the later years. Women need to be educated on the nutritional benefits of using blended oils in cooking as stated by Lakshmipriya et al. (2012).Active physical exercise of atleast one hour daily needs to be advocated for subjects aged between 20 to 35 years. Nutritional education should be actively advocated in schools so the children of obese subjects imbibe healthy eating habits.

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