CHAPTER VII

SUMMARY AND CONCLUSIONS
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One of the greatest public health challenges of recent times is preventing the epidemic of obesity. Although this concern is evident in many western countries, the Asia-Pacific region is yet to give a priority to obesity, either in terms of public health policies or treatment agendas. However, along with an improvement in the socio-economic status in this region, the prevalence of obesity and associated Noncommunicable Diseases (NCDs) is increasing dramatically. Only in recent years, data on prevalence of obesity in South-East Asian regions has been reported. The World Health Organization (WHO) and other taskforces therefore suggest that population screening for obesity & NCDs in order to estimate its prevalence, consequences and cost in the Asian region, must be begun. This data must be then used to implement effective obesity prevention and treatment strategies (WHO, 2000b).

However in Asia, the pattern of metabolic diseases is different (WHO, 2000b). Asians have an increased tendency for abdominal fat accumulation (Snehalatha et al. 1997; Banerji et al. 1999; Chandalia et al. 1999; Raji et al. 2001) and hence, in spite of a lower prevalence of obesity in Asia, metabolic diseases tend to occur at lower Body Mass Index (BMI) levels (Deurenberg et al., 2002; Yajnik, 2001). Thus, cutoffs of anthropometric indicators viz. BMI for assessing overall obesity and waist circumference (WC) for assessing abdominal obesity, that have been derived from studies on Caucasians, may not be suitable for Asians (WHO, 2000b). The relative association of anthropometric indicators and their sensitivity for determining NCD risks among Indians also has not been thoroughly investigated. Thus, the present study was undertaken to study the various aspects of association between obesity and NCD’s with a focus on the more potent abdominal obesity, among urban affluent adults in India. In view of reported Indian studies (Gopalan, 1998) highlighting the fact that obesity and NCD risks are relatively more in economically forward urban rather than rural areas, our investigation focused on urban affluent men in the city.

Obesity is caused due to an imbalance of energy intake and expenditure (Bray, 2004), and hence, investigating the role of diet and physical activity in its development is critical. In view of the extreme diversity in diet, culture, religion and lifestyle found in different states of India, a consideration of these factors while
examining NCD risks in Indian populations is essential. Most Indian studies report prevalence and studies taking a holistic approach to NCD risks are lacking. Therefore, the present study was considered essential and planned with the following specific objectives:

1. To investigate the effect of diet and physical activity patterns on abdominal obesity and NCD risks among urban affluent adults from India.
2. To study the association of anthropometric indices for assessing abdominal obesity with NCD risks among urban affluent adults from India.
3. To determine the cut-off points for indices of obesity and abdominal obesity, for screening individuals with risk of NCDs.

The present study adopted a cross-sectional design and the study protocol was approved ethically by the Institutional Committee. Members of Rotary Clubs generally represent well-educated, professional and higher income section of the population. A formal presentation was arranged for the club members in which issues such as obesity, its causes, consequences and role of diet and exercise in its prevention were discussed. Members voluntarily registered for the study and written consent was taken prior to data collection. Obesity Assessment Camps were organized in the institute on holidays, early in the morning to collect anthropometric measurements and fasting blood sample (10 ml). Blood collection was performed by a trained technician from an authorized pathological laboratory and necessary care was taken for preservation of blood samples for further analysis. Thus, data were collected on 302 men aged 30-60 years.

Anthropometric measurements included body weight (kg), recorded using an electronic weighing balance (Suysan, India) up to 20g and height (cm), recorded with a stadiometer (UNO & Co, India) up to 0.1cm. Percent Body Fat [BF (%)] was measured using a body fat analyzer (HBF300, OMRON Corporation, Japan) which works on the principle of bio-electrical impedance analysis (BIA). Circumferences were measured (up to 0.1 cm) at 3 sites i.e. waist circumference (WC), abdominal circumference (AC) and hip circumference (HC) using a non-stretchable fiber glass measuring tape. Skinfold thickness was measured (up to 0.1 mm) at four sites i.e. triceps (TSF), biceps (BSF), sub-scapular (SSF) and supra-iliac (SUF) using Harpenden’s calipers. All investigators were trained and an inter observer variability
(IOV) study was done prior to data collection. Since maximum variation was seen in case of skin fold measurements, the investigator with lowest standard deviation for skin folds was kept constant for the particular measurement during the study, thus reducing personal error.

Socio-economic information was collected using a structured questionnaire. Information on self medical history, family history of obesity and NCDs was also taken. Assessment of dietary pattern was done, (a) quantitatively using a 24-hour dietary recall questionnaire to get an estimate of a typical day’s nutrient intake and (b) qualitatively using a food frequency questionnaire (FFQ) with a reference period of 1 month to get the information on the habitual pattern of diet. The FFQ contained 17 discriminatory food groups. Similarly, with the help of a physical activity questionnaire, data was collected on the frequency and time spent on routine activities performed in day such as occupation, sleep, recreation, indoor and outdoor sports and any special interests. All questionnaires were field tested prior to use in the study for data collection.

NCD risk assessment included blood pressure measurement [systolic blood pressure (SBP) and diastolic blood pressure (DBP)], using a digital machine called the OMRON Blood Pressure monitor (OMRON T4, OMRON Corporation, Japan). The machine was calibrated using a sphygmomanometer on 50 subjects at a medical doctor’s clinic prior to use. The analysis for fasting blood parameters including fasting blood glucose (FBG), insulin, lipid profile i.e. total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), very low density lipoprotein (VLDL) and triglycerides (TG), that was performed at an authorized blood laboratory for obtaining blood reports duly checked by a medical professional.

Obesity, abdominal obesity and NCDs were defined according to the conventional criteria as given in the Table 7.1. Data was analyzed to determine the extent of obesity, abdominal obesity and NCDs prevalent among the urban affluent men. The association between obesity and abdominal obesity indicators was studied. Finally, both the independent and the combined effect of diet, activity and adiposity on the NCD risk factors was investigated. All analysis was carried out using SPSS/PC+ 11.0 version for Windows (SPSS Inc. Chicago IL).
Table 7.1 Assessment of obesity, abdominal obesity and NCDs

<table>
<thead>
<tr>
<th>Definition</th>
<th>Criteria used</th>
<th>Reference</th>
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<tr>
<td>Overall obesity: using BMI</td>
<td>BMI $\geq 25$ kg/m$^2$</td>
<td>WHO, 2000b</td>
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<tr>
<td>Overall adiposity: using BF (%)</td>
<td>BF $\geq 25$ %</td>
<td>WHO, 1995; Lohman et al., 1997</td>
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<tr>
<td>Abdominal obesity: using WC</td>
<td>WC $\geq 90$ cm</td>
<td>WHO, 2000b</td>
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<tr>
<td>Abdominal obesity: using waist to hip ratio (WHR)</td>
<td>WHR $\geq 0.9$</td>
<td>WHO, 2000b</td>
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<tr>
<td>Hypertension</td>
<td>SBP/DBP $\geq 140/90$ mmHg or use of anti-hypertensive medication</td>
<td>Chobanian et al., 2003</td>
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<tr>
<td>High fasting blood glucose (FBG)</td>
<td>FBG $\geq 110$ mg/dl</td>
<td>IDF, 2006</td>
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<tr>
<td>High insulin</td>
<td>Insulin $\geq 13.1$ mIU/ml</td>
<td>Q3 value</td>
</tr>
<tr>
<td>High homeostasis model assessment – insulin resistance (HOMA-IR)</td>
<td>HOMA-IR $\geq 2.85$</td>
<td>Q3 value</td>
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<tr>
<td>Dyslipidemia</td>
<td>TG $\geq 150$ mg/dl or TC $\geq 200$ mg/dl or LDL $\geq 130$ mg/dl or HDL $\leq 40$ mg/dl</td>
<td>NCEP-ATP3, 2001</td>
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<tr>
<td>High TG/HDL</td>
<td>TG/HDL $\geq 3.0$</td>
<td>McLaughlin et al., 2003</td>
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<tr>
<td>Metabolic Syndrome (MS-NCEP)</td>
<td>WC $\geq 90$ cm, TG $\geq 150$ mg/dl, HDL $\leq 40$ mg/dl, BP $\geq 130/85$ mmHg, FBG $\geq 110$ mg/dl</td>
<td>NCEP-ATP3, 2001</td>
</tr>
<tr>
<td>Metabolic Syndrome (MS-IDF)</td>
<td>WC $\geq 90$ cm + any 2: TG $\geq 150$ mg/dl, HDL $\leq 40$ mg/dl, BP $\geq 130/85$ mmHg, FBG $\geq 100$ mg/dl</td>
<td>IDF, 2006</td>
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Assessment of obesity: Obesity is a major risk factor for NCDs and its assessment is of prime importance for screening individuals at risk of NCDs.

- **Prevalence of overall and abdominal obesity:** Prevalence of obesity based on BMI was high (57.3%), while that based on BF (%) was much higher (73.5%). Our data thus indicated that Indians have higher BF (%) at similar levels of BMI, compared to western populations. Prevalence of abdominal obesity based on WC (33%) or WHR (31%) was almost half of the prevalence of obesity and increased with age.

Mean WC, abdominal circumference (AC) and waist to height ratio (WHT) increased linearly from lower to higher quartiles of BMI or BF (%) showing significant association with overall obesity. However, waist to hip ratio (WHR) and skinfolds showed lower values of correlation coefficients with BMI and BF (%) than the circumferences.

Diet and obesity: Dietary data both from 24 hour recall and FFQ was analyzed to see its association with obesity.

- **Nutrient intake and obesity:** Although mean values of all abdominal obesity indicators (WC, AC, WHT, WHR) increased significantly (p<0.05), with increase in intake of total calories and fat, the prevalence of abdominal obesity increased only when assessed using WC. Subjects having higher daily calorie intake (>1800 kcal) had a 2 times higher significant risk (p<0.05) for both overall and abdominal obesity as compared to those consuming less calories (<1500 kcal). Fat intake however showed such risk, exclusively for abdominal obesity, in subjects consuming more than 50 g of daily total fat as compared to those consuming less than 36 g. Abdominal obesity as indicated by high WC, thus showed significant association with both fat intake as well as total calorie intake.

- **Habitual food consumption pattern and obesity:** Out of the 17 discriminatory food groups, 7 food groups viz. milk products, fried snacks (home-made), fried snacks (marketed), outside snacks, outside meals, sweets and soft drinks showed association with obesity and abdominal obesity. Mean values of WC and prevalence based on it
increased significantly (p<0.05) with higher consumption in case of all food groups, except outside meals. The association was highest for home-made fried snacks [odds ratio (OR): 3.96, p<0.01] and home-made sweets (OR: 3.41, p<0.01). Outside meals specifically showed association with BF (%) and subscapular skinfold (SSF) and supra-iliac skinfold (SUF). Our data thus showed that consumption of fat and sugar rich foods more than 2 times a week, even if they are made at home, increases risk for overall and abdominal adiposity.

Thus, data from both the 24 hour recall and the FFQ method highlighted the importance of fat intake / fat rich foods as a yardstick to be considered in prevention of particularly, the abdominal obesity as indicated by WC. We also observed that FFQ was better than 24 hr recall in bringing out the diet-adiposity associations as it identifies both the food groups and their frequency associated with risk of adiposity.

Activity and obesity: The important contribution of physical activity in maintaining an energy balance cannot be denied and hence its association with obesity was studied. It was observed that after spending about 7.5 hours in sleep and almost 9 hours in occupational activities, subjects spent more than 2 hours of the day’s active time in recreational activities such as TV watching and reading. On the contrary, less than 30 minutes were spent by the subjects in any kind of outdoor physical activity.

Higher time spent in recreation (≥ 3 hours/day) was not only associated with higher mean values of BMI, WC, AC, WHT and SSF, but also increased risk for abdominal obesity (OR: 3.21, p<0.01). Higher time spent in inactive behavior (recreation plus nap time) of > 4 hours/day showed 3 times significant risk (p<0.05) for abdominal obesity. On the contrary, with increase in outdoor activity time (≥ 60 minutes/day), there was a significant (p<0.05) decrease in the mean BF (%) and SSF and the prevalence of abdominal obesity (from 35% to 21%). These findings thus emphasize the role of inactive behavior in the development of adiposity. As measurement of physical activity in large field-based studies is extremely difficult, it may be more beneficial to assess time spent in inactive behavior.
Diet, activity, lifestyle factors and obesity:

Among the lifestyle factors viz. smoking and alcohol, it was alcohol that showed a significant association with both overall and abdominal obesity. It was seen that higher consumption of fat and sugar rich foods as well as higher inactive time continued to show a significant independent effect on the development of both overall as well as abdominal obesity, even after adjusting for alcohol.

Prevalence of NCD risks among urban affluent men: In view of high prevalence of NCDs being reported from various regions of India, the extent of this problem was examined among urban affluent men from Pune, a major city in the western region of India.

Age-related trends were observed for risk of hypertension, high FBG, high insulin and high HOMA-IR and hence age-adjusted prevalence of the respective NCDs were used in the analysis. Overall prevalence of NCDs for hypertension (36.4%), high FBG (10.6%), high insulin (25.2%), high HOMA-IR (24.4%), dyslipidemia (52.3%), high TG/HDL (36.1%), MS-NCEP (13.9%) and MS-IDF (14.2%) was quite high among the present study subjects and was similar to that reported by other Indian studies (Gupta et al. 2004; Kaur et al. 2010).

Obesity and NCD risk: Mean values of SBP, DBP, FBG, Insulin and HOMA-IR and their prevalence were higher in the higher quartiles of BMI and WC. The risk of hypertension was 2.4 times higher among subjects in the highest quartile of WC (i.e. beyond Q3: 91.3 cm) and that for high insulin and high HOMA was seen at an earlier point (i.e. beyond Q2: 86.5cm), while the risk of high FBG was seen even beyond the first quartile of WC (i.e. beyond 81.6cm). Additionally, significant risk for altered lipid profile (high TG/HDL) was observed only across WC quartiles, also at a lower level i.e. beyond Q1. Further, the risks continued to be significant only across quartiles of WC for high FBG and high TG/HDL, even after adjusting for BMI. A strong ability of WC to predict multiple risk was also apparent as similar trends were also seen for metabolic syndrome (MS) by both definitions. It was thus evident that among all the indicators, WC had higher sensitivity for predicting maximum and multiple NCD risk, that too at much earlier levels.

On performing univariate and multivariate regression analysis, it was seen that BMI loses its significance when either WC or WHT are entered in the model for
predicting NCD risk. WC showed highest predictability i.e. \( R^2 \) for HOMA-IR (\( R^2: 11.8 \)) than hypertension (\( R^2: 4.4 \)) or disturbed lipid profile (\( R^2: 5.1 \)). Sensitivity of WC further increased among subjects with BMI more than 26 kg/m\(^2\) (mean value) as the \( R^2 \) for HOMA-IR increased substantially (\( R^2: 19.2 \)). The exercise thus asserts that abdominal obesity assessed using WC is a significant and independent predictor of NCD risks and also highlights that its importance increases beyond a certain level of overall adiposity, especially in predicting the risk of disturbed glucose metabolism.

**Optimal cutoffs of anthropometric indicators for predicting NCD risk:** Optimal cutoffs are important in terms of their practical utility and therefore we performed Receiver Operating Characteristic Curve (ROC) analysis and estimated them for all indicators of overall and abdominal obesity.

Our data showed that the BMI cutoff (25.3 kg/m\(^2\)) for the urban affluent men for predicting NCD risk, was closer to the conventional cutoff of 25.0 kg/m\(^2\) given by WHO (2000b), but was lower for both WC (86 cm) and WHR (0.88) compared to conventional cutoffs (90 cm and 1.0 respectively). A lower optimum cutoff in case of WC implies that 21.5% of our subjects at risk of NCDs could not be identified using the conventional WHO cutoff. In contrast, a higher cutoff was seen in case of percent BF (27.7%) as compared to 25% (WHO, 1995; Lohman et al., 1997) and requires further investigation.

Studies from within India on different populations, have reported even lower optimal cutoffs of WC using the same method of ROC viz. Snehalatha et al. (2003) report 85 cm for men from urban population, irrespective of the social class, while Deshmukh et al. (2006) report 72.5 cm for men from a rural population. This indicates that the cutoffs for WC vary greatly for populations of different socio-economic classes or of different regions (urban/rural) or different ethnic origins. Therefore, population-specific optimal cutoffs need to be identified which can be useful for screening mass populations for NCD risks in epidemiological studies.

**Diet, activity, lifestyle factors and NCD risk:**

*Diet and NCD risk:* It was seen that mean insulin and HOMA-IR and prevalence of high FBG increased significantly (\( p<0.05 \)) with increase in fat calories (%) showing 3 times significant risk (\( p<0.01 \)) among subjects consuming more than 30% of fat calories daily as compared to those consuming less than 20% fat calories. Thus, fat
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calories (%), a more refined marker of fat intake performed better for determining individual NCD risk.

In case of MS, total calories as well as total fat intake continued to show significant risk (p<0.05) of more than 2.5 times even after adjusting for BMI. Among the food groups which had earlier displayed a risk for developing abdominal obesity, continued to demonstrate a positive association with MS. It was predominantly the high consumption of fat rich fried snacks and outside snacks (> 2 times/week) that showed significant risk of more than 3 times (p<0.05) for MS even after adjusting for BMI. Additionally, the beneficial effect of consuming fish was seen as high fish consumption (> 1/week) was associated with lower prevalence of MS.

Among the lifestyle factors considered, the harmful effect of smoking was evident as mean levels of HDL were lower, while that of TG and TG/HDL ratio were higher, along with a high prevalence and risk of TG/HDL among subjects who smoked as compared to non-smokers.

Activity and NCD risk: Among the individual NCD risks, mean levels of FBG, insulin and HOMA-IR and their prevalence decreased with an increase in outdoor sports activity. A significantly reduced risk (OR: 0.32, p<0.05) for high HOMA-IR was observed among subjects engaging in more outdoor sports activity (>60 minutes/day) as compared to subjects with less outdoor sports activity (<30 minutes/day). On the contrary, increase in the recreation time (> 3 hours/day) showed a significant risk of about 2 times for MS which remained high even after adjusting for BMI. Thus, inactive behavior that had earlier shown association with abdominal obesity which continued to pose a risk for MS as well.

Diet, activity and NCD risk: When diet and activity were considered together for determining NCD risk using MLRA, it was only the inactive time (> 4 hours/day) that remained as the independent predictor for risk of MS, with a significant (p<0.05) risk for MS of more than 2.5 times even after adjusting for BMI. Neither the food groups nor fat intake remained significant in presence of inactive behavior.

Combined effect of diet, activity and adiposity on NCD risk: Finally, MLRA was also performed by taking all indicators that had shown significant association with
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MS i.e. BMI (overall obesity), WC (abdominal obesity), significant food groups and inactive time to determine their independent influence after adjusting for the effect of alcohol, smoking and heredity.

Highest quartile of BMI showed marginal risk for hypertension but showed significant risk for isolated SBP (OR: 23.9, p<0.01) and isolated DBP (OR: 7.12, p<0.05). In case of WC, for NCD risks namely high FBG, high insulin, high HOMA-IR as well as MS, a significant OR was observed beyond Q2 value (WC > 86.5cm). However, risk for high TG/HDL was seen at an even lower level i.e. beyond Q1 (WC > 81.6 cm). Thus, WC emerged as a significant independent predictor of NCD risk when all confounders were considered together.

Among the food groups, outside snack and meal consumption remained significant predictors of high FBG, dyslipidemia and high TG/HDL even in the presence of abdominal obesity, while inactive time lost its significance in the presence of diet and adiposity indicating that perhaps it operates through abdominal obesity.

Conclusions and Implications: In conclusion, our study examines the influence of diet, activity and adiposity on NCD risks in urban affluent adult Indian men. Several important findings emerge from the analysis of this study. Firstly, WC comes out as a single indicator which shows highest predictability for risk of NCDs, especially that for HOMA-IR. It shows its significance irrespective of considerations such as quartiles/tertiles/arbitrary groups and from the simplest to the sophisticated analysis. It also shows the strongest association with both diet and activity, thus demonstrating its universal superiority. However, the fact that the optimal cutoff based on our study is much lower than the conventional cutoff suggests that about 21% of people having NCD risk would be missed out if the conventional cutoff is used.

Secondly, even in the presence of adiposity, the importance of diet was brought out. It mainly highlighted the importance of fat intake / fat calories / fat-rich foods in determining NCD risks. The observation also underscores the potential of simple FFQ in examining these associations. The public health nutrition implication of the finding is that eating fat rich foods / snacks / outside meals (> 2 times/week) increases the risk for abdominal obesity and in turn risk for NCDs.

Thirdly, even the simple activity questionnaire was able to bring out the association with abdominal obesity and NCD risks, in particular, the observation highlighted the fact that rather than activity, it is the inactive time that is more
important in determining risk for adiposity and NCDs. Considering the fact that assessing physical activity in field conditions is extremely difficult, our observation that it is the inactive time (>4 hours/day) that confers the risk of adiposity and NCDs assumes importance.

When diet, activity and adiposity (BMI as well as WC) are considered together, it is the abdominal adiposity as assessed by WC that comes out to be the most important predictor of NCD risk. WC being a simple indicator, the observation highlights its use for screening NCD risks in large populations. It will also be a useful indicator for monitoring purposes, but needs to be validated. Finally, in view of the fact that Asian populations have relatively high BF at lower BMI, that is preferentially deposited in the abdominal region, our observation has wider implications in similar settings.

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