CHAPTER I

INTRODUCTION
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‘The World is Fat: more people in the developing world are now overweight than hungry’. This title of an article in the August 2007 issue of the ‘Scientific American’ by Dr. Barry Popkin, pertinently describes one of the major concerns faced by the human race today i.e. Obesity.

1.1 Global epidemic of obesity:

Parallel to the soaring obesity rates are the increasing numbers of individuals who are abdominally adipose. Reports from developed countries such as UK (NHS, 2010), developing nations across the world (Balkau et al., 2007), including India (Gopalan, 1998; Reddy et al., 2002) indicate that the prevalence of abdominal obesity is rapidly surpassing that of overall obesity. As a consequence, there has also been a concomitant rise in the adiposity related Noncommunicable Diseases (NCDs). Thus, out of the 57 million worldwide deaths in 2008, 36 million were due to NCDs, comprising mainly of cardiovascular diseases (CVDs), diabetes, cancers and chronic lung diseases. Augmented cause of concern is that this enormous burden of abdominal obesity and NCDs is more detrimental for developing countries where 80% of all NCD deaths occur, especially among persons aged less than 60 years (WHO, 2011a). Thus, while the importance of obesity has been realized by health professionals from a medical perspective, it also needs to be recognized as a symptom of a much larger global social problem (WHO, 2000a).

Importance of abdominal obesity: In the past, physicians were constantly challenged by the absence of metabolic complications in some very obese patients, while certain overweight patients displayed a cluster of metabolic abnormalities that substantially increased the cardio-metabolic risk. It was French physician Jean Vague (Vague, 1956) who first reported that the location of the excess fat was more important and that the male pattern of fat distribution with increased abdominal fat deposition determined the complications generally found in obese patients. This variation in body fat distribution was further made evident by prospective studies in the 1980’s (Larsson et al., 1984; Lapidus et al., 1984; Kissebah et al., 1982, Kissebah and Pelrls, 1989) which showed that abdominal fat was a more potent risk factor for NCDs, independent of total adiposity. Substantial evidence now exists to demonstrate
that regional distribution of fat alters the relationship between obesity, metabolism and health (Bouchard et al., 1990; Despres et al., 1990).

**Asian Indian obesity phenotype:** A unique obesity phenotype is that Asians have higher percentage of body fat (BF %) at a given level of BMI as compared to Caucasians, which seems to be preferentially deposited in the abdominal region (WHO, 2000b; Deurenberg et al., 2002; Misra and Vikram, 2002). However, differences exist even within the Asian populations, with the Indian community referred to as the ‘South Asians’ having a much higher risk of NCDs (WHO, 2000b). Not only do Indians have substantially higher abdominal fat mass than Caucasians as is evident from studies among both native (Shelgikar et al. 1991; Misra et al. 2001; Snehalatha et al. 2003) as well as immigrant Indians (McKeigue et al. 1991; Banerji et al. 1999; Chandalia et al. 1999; Raji et al. 2001), but they also have higher body fat as compared to other Asians (Deurenberg-Yap et. al., 2000; Lear et al., 2007a). As a result, South Asians demonstrate highest coronary heart disease (CHD) mortality rates compared with individuals of Chinese and European descent (Sheth et al., 1999; Enas et al., 2007). Thus, Indians seem to be the most vulnerable group for development of NCDs, observed at lower levels of adiposity and also at much younger ages as compared to Caucasians and even other ethnic groups (Misra and Khurana, 2011).

**1.2 The Indian paradox:**

Post Independence, India has witnessed an impressive economic growth, however, about one third of the population still falls below the poverty line. As a result, there exists a double health burden of poverty related diseases associated with infections and undernutrition which are being exacerbated by obesity and NCDs associated with increasing affluence. This unsettling modern-day paradox is putting severe limitations on health resources, further compounding the problems (Gopalan 1998, 2008; Mohan and Deepa, 2006).

**Nutrition transition:** Consequential demographic and economic changes lead to ‘Nutrition Transition’ which involves large shifts in the diet and activity patterns, which are further reflected in the nutritional outcomes such as stature and body composition (Popkin and Gordon-Larsen, 2004). Data from the National Sample Survey (NSS, 2001) in India shows that as the socio-economic scale ascends, there is
a decline in the cereal and pulse intake, but a substantial rise in the intake of sugars, fats and animal products. Fiber and micro-nutrient content of the diets are substantially reduced as the relatively cheaper coarse grains and millets are being replaced by the pricier refined wheat and rice. Due to globalization of the food market, there has been an increasing acceptance of fast foods and sweetened beverages which are high in fats and sugar (Gopalan, 1998, 2008). The term “Coca-colonization” (Zimmet, 2000) has been coined to indicate the huge presence of Coca-Cola, Pepsi along with fast food giants such as McDonald’s all across the world, including India. Urbanization with increased aping of the western pattern of diet has thus fueled these changes in diet patterns in developing countries, which are the most rapid and dramatic in the course of human history (Hu, 2008). Along with dietary shifts, the transition has also resulted in sedentary lifestyle, increasing the inactive behavior in urban populations. The adverse consequence of such Nutrition Transition in India has hence been a surge of obesity, abdominal obesity and related NCDs.

1.3 Fetal origins of adult diseases:

Evidence is accumulating in the last two decades showing inverse association of birth weight with NCD risks in adulthood. Thus, fetal adaptation to maternal undernutrition is believed to ‘programme’ NCD risk in later life (Barker, 1998). However, most of these studies are reported from developed countries rather than developing countries. Secondly, the hypothesis is supported by retrospective cohort studies, wherein the information on maternal diet is often not available. The studies have clearly brought out the fact that small babies with high adult BMI are the most vulnerable for NCD risk. However, additional investigations are required on the critical pre and post natal time periods during which nutritional exposures programme later health (Koletzko, 2005). Similarly, along with adult BMI, role of diet and activity needs to be taken into consideration in examining this hypothesis which is particularly relevant in India, given the pace of Nutrition Transition over the last two decades (Kurpad et al., 2011).

1.4 Prevalence of NCDs in India:

It is worthwhile to note the latest reports from The World Bank (Engelgau et al., 2011) indicating that by 2030, CVDs are expected to emerge as the main cause of death in India. Further, South Asians suffer their first heart attack six years earlier
than other groups worldwide. India leads in the prevalence of diabetes in the world with about 50.8 million diabetic Indian adults (Shaw et al., 2010) and this sadly makes India the diabetes capital of the world. With predictions of about 50% of the Indian population being urbanized by 2025 (Gopalan, 1998), there can certainly be a premonition of further worsening of the obesity and NCD epidemic.

“As the Indian economy is growing, India’s middle class is accumulating fat around the middle at an alarming rate” (CSE, 2005). Studies have reported (Reddy et al., 2002) an alarming 70% prevalence of abdominal obesity in comparison with 35% prevalence of overall obesity among urban Indian men. Parallel to abdominal obesity, the acceleration of NCDs is also to a considerable extent, an urban phenomenon. Several studies have shown that the prevalence of almost all NCDs including hypertension, insulin resistance, diabetes and CHD is higher among urban individuals as compared to the rural populations in both northern and southern India (Chadha et al., 1997; Ramachandran et al., 1992). Further, the prevalence of hypertension has increased from about 11% in 1997 (Chadha et al., 1997) to about 40-50% in 2004 in North India (Gupta et al., 2004a, Misra et al., 2006). Such rapid increase is also reported in case of diabetes among South Indian urban population with evidence that almost every fifth individual in the southern city of Chennai is a hypertensive (Mohan et al., 2007).

The high prevalence of ‘Metabolic Syndrome (MS)’, a clustering of metabolic diseases, is also a characteristic of the urban population, especially the higher socio-economic class, as revealed by studies in India (Gupta et al., 2004b; Kaur et al., 2010). Additionally, studies also have reported higher prevalence of NCDs among men as compared to women (Gupta et al., 2011; Iyer et al., 2011). It thus becomes evident that it is the urban affluent male population, that is particularly at a high risk of developing NCDs associated with obesity and abdominal obesity. These grim figures clearly portray that barely escaping the clutches of poverty and hunger, India is now being engulfed by an epidemic of abdominal obesity and NCDs.

1.5 Abdominal obesity and NCD risks:

In view of the fact that both obesity, especially abdominal obesity and prevalence of NCDs are not only higher in urban population but are showing increasing trends which are of nutritional concern, it becomes imperative to identify simple indicators for assessing abdominal obesity and to examine their associations
with NCD risks. In fact, it is reported that the association between blood pressure and stroke is so strong in Eastern Asia, that a reduction of even 3 mmHg in diastolic blood pressure would reduce the number of strokes by one-third (Eastern Stroke and Coronary Heart Disease Collaborative Research Group, 1998). Therefore, a critical scrutiny of simple indicators with higher predictive power, so as to use them for screening the masses for early detection of NCDs, has an important societal implication.

**Indicators of abdominal obesity and their thresholds:** Although overall obesity has been conventionally assessed using BMI, a differential preference for indicators to assess abdominal obesity is evident from published Indian studies. Early reports of prevalence of abdominal obesity among urban populations from North India by Gopalan (1998), followed by several other studies (Ramachandran et al., 2001; Mohan et al., 2001; Reddy et al., 2002), were based on the use of Waist to Hip Ratio (WHR). However, results based on the association of WHR with NCDs have been inconsistent. For instance, among South Indian populations, Ramachandran et al. (1992) have reported a significant association of WHR with Diabetes, while Shanthirani et al. (2003) observed that WHR was not a good predictor of hypertension in the presence of BMI. As such several experts (Bouchard et al., 1991; Despres et al., 1990; Lean and Han, 2002) have discouraged the use of WHR in view of its weak association with intra-abdominal fat, insensitivity to changes due to weight loss and difficulty in biological interpretation and alternately have ascribed the utility of WC, a more direct measurement of abdominal adipose tissue.

A good correlation of WC with deep abdominal adipose tissue has been reported among Indian (Brundavani et al., 2006) as well as Caucasian adults (Pouliot et al., 1994). Mohan and Deepa (2007) are of the opinion that WC is a simple and reliable estimate of CVD risk although several arguments exist in favor or against this simple yet technically demanding measure. A group of researchers (Parikh et al., 2007; Parikh et al., 2009; Parikh, 2011) have also advocated the superiority of waist to height ratio (WHT) over WC in not only predicting CVD risk, but also for defining MS among Indians. In contrast, another group of scientists (Gupta et al., 2007; Gupta and Gupta, 2008) have reported that indicators of obesity such as BMI, WC, WHR and WHT are equal in predicting CVD risk. Consequently, the controversy still exists
regarding the relative efficiency of abdominal obesity indicators among Indians for predicting NCD risks.

Other indicators such as sub-scapular skinfold thickness, a measure of truncal subcutaneous fat, although has demonstrated good associations with insulin resistance among migrant Asians Indians (Chandalia et al., 1999), has rarely been used among native Indians (Misra et al., 2005a). Additionally it may also be noted that, scarcely any studies (Singh et al., 1999) have considered the measurement of body fat using simple techniques such as Bio-electrical Impedance Analysis (BIA) for assessment of overall obesity. Thus, further studies that examine multiple overall and abdominal obesity indicators which are also good predictors of NCD risks across different Indian populations are necessary to arrive at definite conclusions.

Another important point of consideration is the lack of consistency in the choice of cutoffs that have been used to define abdominal obesity. Gopalan (1998) had used older cutoffs of WHR i.e. 1.0 for men and 0.85 for women for assessing abdominal obesity, however, subsequent to reports by World Health organization (WHO, 2000b) that the cutoffs require revision for use among Asians, studies have used a wide array including 0.95 for men and 0.8 for women in North Indian population (Misra et al. 2001), 0.9 for men and 0.85 for women in South Indian population (Mohan et al. 2001) and 0.9 for men and 0.8 for women used by Ramachandran et al. (2001) for urban population in six cities. A similar scenario exists in case of WC, for instance, the WC cutoff among men in reported Indian studies varied from 102 cm (Gupta et al., 2004a), 90 cm (Kamble et al., 2010; Kinra et al., 2010) and 80 cm (Bose et al., 2003). Thus, variation in thresholds of abdominal obesity indicators makes it difficult to compare the prevalence rates between studies. It is therefore warranted that the use of arbitrary cutoffs should be supplanted with optimal cutoffs determined using appropriate statistical techniques.

**Determining optimal cutoffs of overall and abdominal obesity:** Overall obesity defined using BMI cutoffs (25 kg/m^2 for overweight and 30 kg/m^2 for obesity) and abdominal obesity defined using WC cutoffs (102 cm for men and 88 cm for women) are currently used for NCD risk assessment among Caucasians (WHO, 2000a). However, in light of findings that metabolic diseases occur at lower levels of BMI and WC among Asians, these cutoffs may not be appropriate for use among Asians and a revision of cutoffs may be required. Lower cutoffs of BMI (23 kg/m^2 for overweight
and 25 kg/m² for obesity) and WC (90 cm for men and 80 cm for women) for Asian populations have been suggested by WHO, but have not been established due to lack of sufficient supporting data from the Asian region (WHO, 2000b).

Statistical techniques such as Receiver Operating Characteristic (ROC) curves now accepted as suitable for determining optimal cutoffs on anthropometric indicators (WHO, 2011b; Rao, 2011). However, wide variations have been observed among the few reported Indian studies attempting to arrive at optimal cutoffs of overall and abdominal obesity using ROC. The variation in ROC cutoffs is mainly due to the differences in populations studied and due to the disease for which the risk cutoff is estimated. Thus, the appropriateness of the indicators and its optimal cutoff are very much dependent on the disease (hypertension vs. diabetes) and the population being studied for the risk. Thus, a wide variation in cutoffs is seen not only in case of different populations within Asia such as Chinese (Li et al., 2002), Thai (Aekplakorn et al., 2006), Taiwanese (Pan et al., 2004) and Korean (Park et al., 2010), but also in case of populations within India (Snehalatha et al., 2003; Misra et al., 2006; Deshmukh et al., 2006; Kamble et al., 2010). Additionally, the conventional cutoffs may not be suitable in case of populations experiencing early undernutrition. For example, in case of Guatemalan population, it has been shown that cutoffs are much lower in case of stunted subjects as compared to non stunted (Gregory et al., 2008). Therefore, the need for having customized cutoffs of indicators separately for specific populations, for predicting NCD risks cannot be denied.

1.6 Major confounders of NCD risks:

Fat storage, which was a protective mechanism during our evolution, for survival during frequent famines is working against us in today’s affluent times where food is plenty and majority of the world’s population regularly overeats (Ramachandran, 2004). Although India is considered to be in midst of a ‘Nutrition Transition’, where dietary shifts parallel a rapidly escalating epidemic of obesity and NCDs, Indian diets have not been thoroughly investigated (Daniel et al., 2011).

Often the role of diet has been studied in isolation either in the context of obesity or CVD risks, but is hardly studied jointly. Thus, high fried food consumption or a high total fat intake has been reported to be significantly associated with the risk of developing obesity (Vadera et al. 2010; Dua and Seth, 1988) while a high fish consumption is shown to have an inverse relation with CHD mortality (He et al.,
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2004). For example, studies among urban Indians (Daniel et al., 2011) found dietary patterns characterized by animal products, fried snacks, or sweets to be positively associated with abdominal adiposity, but did not investigate association with NCD risks. However, Ghosh et al. (2003) reported frequent consumption of egg, fried snacks and milk-based sweets to be positively associated with abdominal obesity as well as with abnormal lipid and glucose profile among urban men from Eastern India. Enough evidence is lacking on whether diet has an independent role in the development of NCDs, or its effect is mediated through increased adiposity.

Another major confounder for abdominal obesity and risk of NCDs is physical activity. Although high-income countries have a higher prevalence of insufficient physical activity, its prevalence is also rising rapidly in low and middle-income countries (WHO, 2011a). The health benefits of physical activity are well documented and include maintenance of weight loss, reduction in BP, increase in high-density lipoprotein cholesterol (HDL), and decrease in the risk of death from NCDs, but have been mainly reported in controlled trials among Caucasian populations (Warburton et al., 2006). However, epidemiological evidences reveal inconsistent results probably owing to difficulties in measurement of physical activity. Paucity of data examining the role of physical activity in development of obesity and subsequent health risks is even larger among Asian Indians. There is therefore a need for formulating appropriate tools for the objective assessment of physical activity or inactivity which may be relatively easier to measure. Additionally, under-reporting in case of dietary information (Schoeller et al., 1990) and possible over-reporting in case of physical activity information (Irwin et al., 2001) are well known.

Among the few reported Indian studies, individuals with higher levels of physical activity were reported to have a lower prevalence of diabetes and impaired glucose tolerance (Viswanathan et al., 1996). However, scarcely any studies have simultaneously examined both dietary components and physical activity. Similarly, Beegom et al. (1995) found no independent association of diet and activity with hypertension although they reported that abdominally obese subjects who had higher risk for hypertension also had higher dietary fat intake and lower energy expenditure. These observations suggest that the effects of confounders are mediated through abdominal obesity. In particular, the fact that weight loss based on diet (Sasakabe et al., 2011) and activity (Mayo et al., 2003) interventions substantially reduces abdominal adipose tissue, the importance of these confounders need to be further
explored from the point of view of public health nutrition. Finally, lifestyle factors such as smoking and alcohol consumption are behavioral traits contributing to the risk of NCDs and their presence cannot be ignored, especially in metropolitan settings (WHO, 2011a). Further, the importance of heredity in the context of obesity and NCD risk cannot be ruled out (Rao et al., 2010). Thus, a holistic approach in understanding abdominal obesity and NCD risks in the midst of several confounders is required with an attempt to highlight the role of modifiable factors.

Since urban affluent men seem to be the most vulnerable group for development of abdominal obesity and NCDs, the present study was planned with the view of exploring the above issues among urban affluent men from Pune city. Specific objectives of the study were:

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 members of Rotary Clubs in Pune city constituted the study population. Development of survey tools for assessing objectively the habitual dietary pattern and physical activity was an integral part of the research and required considerable initial time in the study. Establishing rapport with presidents of Rotary Clubs and in turn with Rotary members to arrange the Obesity Assessment Camps on weekends at the institute was the logistic through which data was generated to study the above objectives.

The research work carried out is presented in different chapters:
• An informative yet concise review of available literature on prevalence of overall and abdominal obesity, its etiology and assessment, and its association with diet, activity and NCDs is presented in Chapter II.
• Chapter III gives details of all the methods used in the assessment of obesity, dietary intake, food consumption patterns, physical activity and NCD risks including measurement of blood pressure and fasting blood estimations.
Chapter IV is based on the preliminary analysis of the data where prevalence of overall and abdominal obesity among urban affluent men, age related trends, and association of abdominal obesity indicators with overall obesity indicators is given.

• Associations between dietary intake, food consumption patterns and physical activity with overall and abdominal obesity are examined in Chapter V.

• Along with prevalence of NCDs, the role of several factors such as overall and abdominal obesity, diet, activity, lifestyle factors and heredity; independent as well as combined, in predicting NCD risks is investigated in Chapter VI.

• Finally, Chapter VII offers the summary of the major findings of the research study along with its implications.