Man had always been interested in physical work be it recreational or occupation. However, causes of decreased physical work/exercise by man at large have disturbed the energy balance equation. Increased caloric intake, increased consumption of refined carbohydrates and physical inactivity has led to an explosion in the incidence of obesity both general and abdominal. It is also responsible for the emerging epidemic of insulin resistance and metabolic syndrome. By almost any measure, this onslaught of metabolic syndrome threatens to reverse trends in industrialized countries toward increasing cardiovascular diseases. Persistent trends in metabolic and cardiovascular risk have resulted in a rapid research effort focused on built environment, physical activity, gene environment complex and metabolic syndrome.

The prevalence of metabolic syndrome has increased noticeably over the last few decades and has become a major health challenge worldwide, increasing the risk of cardiovascular disease (CVD), type 2 diabetes (T2D), nonalcoholic liver disease, renal disease, and some forms of cancer in adults (Zimmet et al, 2001; Yach et al, 2004). Regular aerobic physical activity increases exercise capacity and plays an important role in both primary and secondary prevention of cardiovascular disease (Chandrasheckhar and Anand 1991; Morris and Froelicher 1991). The present study was conceptualized to understand the physical activity pattern, lifestyle and health indicators among Punjabi adult males and females of Delhi having at least one symptom of metabolic syndrome to full fledged cause of metabolic syndrome as per National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III). The impact or benefit of physical activity (regular or irregular) as compared to sedentary lifestyle has been explored in this research study.

The percentage of metabolic syndrome in present research was found to be 36.1% among adult Punjabi males and females of Delhi. The current search in metabolic syndrome is attributable to an interaction between a genetic predisposition towards efficient energy storage and a permissive environment, readily available food and sedentary or irregular pattern of physical activity.

Present study depicted higher percentage of symptoms of metabolic syndrome among Punjabi males and females of Delhi having sedentary lifestyle followed by, the second
group who followed an irregular pattern of physical activity as compared to regularly active counterparts. Sedentary behavior, persistent low levels of physical activity, and poor cardio respiratory fitness (CRF) are known to predict progression toward CVD, T2D and metabolic syndrome in adults (Laaksonen et al, 2002a; Bassuk & Manson, 2005; Roberts & Barnard, 2005; Duncan, 2006; Ford & Li, 2006).

The irregular pattern of physical activity although is better than ‘no voluntary physical activity’, it may render a subject with a false sense of security of performing physical activity as compared to sedentary group. If counter measures with respect to life style indicators are not taken, then it may increase the risk of metabolic syndrome. The present study found that risk of metabolic syndrome (MS) increased with irregular pattern of physical activity by almost two times when compared with the regular pattern of physical activity. Similar results were found by Hahn et al (2009) who indicated that physical activity performed at regular intervals was more effective than irregular exercise. However some studies reported the risk of metabolic syndrome (MS) among individual with sedentary lifestyle rather than irregular activities (Paffenbarger et al, 1993). The effects of physical activity on MS have been examined in European and American populations, with results showing that physical activity improves the metabolic profile and that those who are physically more active are less likely to have MS (Byberg et al, 2001; Laaksonen et al, 2002b; Zhu et al, 2004).

It was found that Punjabi females showed higher risk of metabolic syndrome as compared to males. Females who were mostly homemakers were not only physically less active, their reporting about physical activity undertaken, may also be exaggerated. The reason for women to be less active could also be that they undertook less modes of voluntary physical activity than men. The common obstacles to physical activity according to female subjects were poor health and lack of interest (P’aivi et al, 2010). Erlichman (2002) reported that data on women are more difficult to interpret because women are less active and the relationship with physical activity is usually less clear.

India is a stratified country in terms of economy, castes, social background and life style patterns but the influence of these strata on obesity and cardio-respiratory health has been less explored. While studying the association of pattern of physical activity with
indicators of metabolic syndrome and respiratory functions among Punjabi adult population it was found that the adult males and females with different patterns of physical activity showed marked differences with respect to various adiposity indices and cardio-respiratory health.

A sedentary lifestyle was found to be associated with high blood pressure, higher general and abdominal obesity, blood sugar level among present study subjects. A sedentary lifestyle being linked to the metabolic syndrome (Ford et al 2005), obesity (Foster et al 2006), and diabetes (Hu 2003) has been reported earlier also. High blood pressure is directly associated with risks of several types of cardiovascular diseases (Kearney et al, 2005). Hypertension and obesity have also been implicated in several studies as a result of rapid modernization (Dressler et al, 1987).

In US only 22 percent of adults are active for health in light to moderate-intense activity i.e., 30 minutes for five or more times per week, and 24 percent or more are sedentary i.e., reporting no leisure time physical activity in the past month (Healthy people, 2000). It has also been estimated that 12% of the annual deaths in the US can be attributed to physical inactivity (Hahn et al 1986; McGinnis and Foege 1993; NIH 1996).

Exercise reported as walking, stair climbing and sports play are found to be related inversely to total mortality, primarily to death due to cardiovascular or respiratory causes (Paffenbarger et al 1986). This review of the epidemiological finding regarding physical activity and cardiovascular disease (CVD) provides substantial evidence from many different populations that leisure time physical activity is associated with reduced risk of coronary heart disease (CHD) and cardiovascular mortality in both men and women and in middle-aged and older individuals. Physical activity appears to be a critical factor in both primary and secondary prevention of CHD. Taking up regular light or moderate physical activity in middle or older age confers significant benefit for CVD and all-cause mortality (Wannamethee and Shaper, 2001).

These findings add new evidence that overall physical activity levels are an important determinant of longevity, and that health benefit can be obtained through an active lifestyle, exercise, or combinations of both (Charles et al 2007).
Our results suggested that targeting physical activity patterns in the present population could be effective in regulating symptoms of metabolic syndrome and therefore in lowering cardiovascular and respiratory disease risk in the study population. Improvement in blood pressure, adiposity indices (BMI, GMT, fat percentage, WHR, WHtR and WC), respiratory functions (FEV<sub>1.0</sub>, FVC, FER, PEFR) was found during follow up among subjects who were regular in their physical exercise as compared to the relatively sedentary group. Regular physical activity was found to be an important factor to decreased risk of metabolic syndrome and lower general and central fat distribution among adult Punjabi males and females of Delhi. Irregular life style was found to be more precarious as it increased the risk of adiposity as compared to sedentary life style.

The three international definitions of metabolic syndrome (MS) were compared in the present study and it was found that with IDF definition highest risk of metabolic syndrome was found among the study subject. The criteria of IDF to assess the prevalence of metabolic syndrome are not appropriate for Indian populations as India is a multi ethnic country and the ranges given by IDF are not apposite for such a wide variation among its inmates. Waist circumference classification according to IDF covered mostly Mongoloid population in Asian category, where as India covers a vast majority of population which are quiet varied in size and shape. The distribution pattern of fat over the body is different among different populations (Kapoor& Kapoor, 2005; Kagawa et al, 2009), and according to IDF, WC is an important marker to assess metabolic syndrome. Among Indian populations except for those of mongoloid origin in north east part of India, the criteria of WC for Asians may not be the most appropriate one. The present study showed that the risk of metabolic syndrome increased when Asian cut offs were used while according to European cut offs the risk reduced. Therefore Asian standards of IDF may not be appropriate to all the Indian population as it may be taxing to them. WHO or NCEP ATP III guidelines of metabolic syndrome seemed more suitable for adult Indian population due to their varied physique type. The prevalence of metabolic syndrome was also found to be similar while using WHO and NCEP ATP III guidelines. According to WHO definition, glucose intolerance was a required symptom for the categorization of metabolic syndrome. Therefore, NCEP ATP III criteria was used for the present study, where any three symptoms out of five, lower
HDL, higher triglycerides, blood pressure, fasting blood sugar, waist circumference defined metabolic syndrome.

Clearly, there are many gaps in our understanding, but with the increasing pace of global epidemic of metabolic syndrome, it is important to evaluate in quantitative terms what would be required for the Indian populations, if effective preventive measures are to be taken.

**Anthropometric variables and indices**

Adult Punjabi males were taller and heavier than the females in both the active and sedentary group. Weight was higher in sedentary group of females and males as compared to active group. The active group included the subjects following regular and irregular pattern of physical activities. Among females, no significant difference was found in height and weight of active and sedentary group.

When the mean values of body weight was seen among irregular and regular group of females, weight was significantly higher in irregular activity group. Height and sitting height showed no significant difference between two groups. Sedentary group had higher mean values for height and weight than regular activity group though the difference was not statistically significant. Similar result was found between sedentary and irregular active females. The subjects being from same population, sharing same gene pool and similar environment may not exhibit much difference in their stature values, which is the outcome of similar growth pattern. However body weight a more modifiable variable does reflect positive or negative energy balance due to physical activity and sedentary lifestyle. Studies have been done which shows positive association between physical activity and weight loss (Pronk & Wing, 1994; Miller et al, 1997; Jeffery et al, 2003).

Circumference is a cross sectional measure of subcutaneous fat, muscle mass and skeleton mass. It measure regional fat, muscle mass and underlying bones. Chest circumference measured at maximum inspiration and expiration provides an index of respiratory functional capacity (Callaway et al, 1988) while waist circumference is an
index of deep adipose tissue (Borkan et al, 1983). Waist circumference is a common measure used to access abdominal fat content.

When used in a ratio with hip circumference it is an indicator of degree of masculine distribution of adipose tissue: the higher the ratio, more masculine the pattern of adipose tissue distribution and the greater the risk of disease such as non insulin dependent diabetes mellitus (Krotkiewski, 1983; Hartz et al, 1984; Ohlson, 1988; Joyce & Kapoor, 1996).

Though hip circumference was higher in females, waist circumference was higher in males, in all the three groups, which showed that females localize excess body fat mainly in hip region and males on the trunk region. Fat on hip region is typical of female and referred to as gynoid fat distribution (Hartz et al, 1984). Regular activity males and females had lower mean value of almost all the circumferences compared to sedentary group and irregular physical activity group. Mid upper arm circumference differed in all the three groups. The regular active group among both males and females showed lower mean value as compared to irregular physical activity and sedentary group. The mean values of all the skinfold thicknesses were also found to be lower among regular activity males and females as compared to other two groups. This finding reflects less fat mass and more lean mass among regular activity groups while higher fat mass among irregular pattern of physical activity and sedentary group. This reflects due partly the difference in activity levels and food habits and partly the limitation of singular circumference as a variable for comparison between such different groups.

There are various methods used for assessing the fatness or energy reservoir in human beings. The simplest is the measurement of skinfold thickness at selected sites over the body. Skinfold thickness sometime called ‘fat fold’ thickness, are actually the thickness of double folds of skin and subcutaneous adipose tissue measured at specific sites on the body. The utility of skinfold thickness is two fold, they provide a relatively simple and non invasive method of estimating general fatness and secondly they characterize the distribution pattern of subcutaneous adipose tissue over the body. The extent to
which the subcutaneous adipose tissue compartment reflects total body fat varies with age, health status, nutritional status among individuals and populations (Kapoor, 2000).

All the skinfold values were higher among males and females with irregular physical activity than in sedentary and regular physical activity groups. Grand mean thickness, a measure of gross subcutaneous fatness was also found to be significantly higher among males and females practicing irregular physical activity. At all the body sites, adult Delhi females had more subcutaneous fat as compared to their counterpart males. The results were consistent with the earlier works (Gopinath et al, 1994; Misra et al, 2001; Sinha and Kapoor, 2006; Tandon, 2006; Kamei, 2007; Mungreiphy, 2009; Gupta, 2010). This difference is mainly due to females having gender specific essential fat. It is not all clear whether this fat is expandable or serves as reserve storage. More than likely, this additional fat is biologically important for child bearing and other hormone related functions. The mammary glands and pelvic region are probably primary sites for this component of essential fat, although the precise amounts are unknown (McArdle, 1994).

Fat mass and fat free mass was higher among adult males with irregular pattern of physical activity. Among females BMR was lower among irregular physical active group and higher among regular activity group. The lower BMR among irregular physical activity group could be because their body after getting adapted to high metabolic rate was again being subjected to low metabolic rate due to irregular physical activity regime. In addition the irregular physical activity group subjects had been taking same amount of calories when they were not doing physical activity regularly and hence causing a positive energy balance. Other factor could be that they tended to eat more because of their false sense of security for doing physical activity which may be irregular.

The distribution pattern of subcutaneous fat was depicted from profile of fatness in both males and females according to level of physical activity. It also depicted the intra and inter group variation in skinfold thickness as also reported by Satwanti et al (1980) in a study to evaluate fat distribution in lean and obese young Indian women. There is influence of genetic factors upon body composition. Bouchard et al (1985) have suggested that genetic factors determine a substantial proportion of the variance in both
overall obesity, and also the distribution of subcutaneous fat between trunk and the extremities.

For many decades emphasis in body composition research had been on patterns of fat distribution and redistribution (Reynolds, 1951; Skerlj et al, 1953; Garn, 1954; Borkan and Norris, 1977; Satwanti et al, 1980; Rimm et al, 1995; Joyce and Kapoor, 1996; Sinha and Kapoor, 2005). Subcutaneous fat distribution pattern as depicted by fat profile differed between different groups engaged in different patterns of physical activity and sedentary life style among adult males and females of Delhi. Maximum mean value of skinfold thickness was found at subscapular site in adult males in different activity groups and sedentary group where as among females it varied among the regularly active group. Irregular active group had calf posterior and sedentary group had subscapular as sites of highest fat stores. Biceps among both males and females showed minimum mean value in three groups. Active and sedentary males showed similar pattern of fat distribution.

The subcutaneous fat distribution difference between active and sedentary females with respect to subscapular skinfold thickness (SUSF) and calf posterior skinfold thickness (CPSF) was observed. Among adult females the group who practiced regular physical activity was not only leaner than their counterparts sedentary group, they also differed in their fat distribution pattern at sites calf posterior (CFPSF) and suprailliac (SUSF). It was found that the mean values of skinfold thickness at these sites were higher among both males and females who followed irregular pattern of physical activity as compared to their counterpart. Similar results of fat distribution and level of physical activity were reported by Bhalla et al (1983), Satwanti et al (1984) and Depress et al (1985).

Subcutaneous fat distribution pattern among adult males and females according to number of metabolic syndrome symptoms was also evaluated. Among males, analogous association has been observed between number of MS symptoms and subcutaneous fat storage pattern. The adult males with three symptoms of MS exhibited maximum fat storage pattern with calf posterior (CFPSF) site having maximum subcutaneous fat. Although the site of maximum fat stores remained same i.e. calf posterior (CFPSF), the
Discussion

Subjects with two and one symptoms were found to be positioned below those of three symptoms holders.

Similarly, among females, in all three groups, the minimum fat store site was biceps (BSF) followed by calf medial (CFMSF). The maximum fat store site in three or more symptom group was found to be suprailiac (SUSF) as compared to calf posterior (CFPSF) in females having one symptom or two symptoms of MS. It depicted central pattern of body fat distribution in which there was more deposition of fat on trunk than extremities among females with three or more symptoms of metabolic syndrome. These females had suprailiac as site of maximum fat storage thus depicting more androidal pattern of fat storage thus predisposing them to cardiovascular problems.

Body mass index has been commonly used as an index of obesity in epidemiological research because of its wide availability and high correlation with percentage body fat (Criqui et al, 1982). An increase in BMI with simultaneous increase in grand mean thickness of skinfold thickness would entail this increase in weight due to increase in fatness. Waist height ratio (WHtR) predicts a wide range of cardiovascular risk factors and related health conditions.

The present study showed mean values of BMI among all the groups to be higher than normal category of BMI. Higher mean values were found among irregular activity males and females followed by sedentary group and regularly activity group. Putatunda and Dhara (1994) reported BMI to be significantly lower in tribal women in all the age groups than that of non tribal women. Sidhu et al (2005) used BMI to study the prevalence rate of overweight/obesity among rural and urban women and found the frequency of overweight/obesity among rural and urban females. High altitude females were leaner than females from plains as adjudged by thickness of skinfold at various sites and also by BMI (Kapoor, 2000). Thus, the reasons for differences in fat mass of different populations could be multiple ranging from socio economic status, food intake, physical activity levels and geographical locations. The high altitude natives were more robust as compared to low landers on the basis of their BMI values. It is in contrast to the finding on Kirghis highlanders who had lower values of BMI as compared to their counterparts from the low altitude (Fiori et al, 2000). BMI is most commonly used index
of obesity which shows sign of ageing as found by Kaur and Kapoor (2003). It was also reveled that the increase in BMI with age were more pronounced in females than in males, both at adolescence and adult stages (Sinha and Kapoor, 2006).

Waist hip ratio (WHR) and waist circumference (WC) were found to be higher in females and males with irregular pattern of physical activity and sedentary lifestyle pattern indicating that they were more centrally obese than those who were regular in their physical activity. Higher values of WHR, waist height ratio (WHtR) showed the group was more disposed to cardiovascular and metabolic health problem. The males with irregular physical activity pattern had 5.51 times, 3.81 times and 13.21 times more chance at risk of increasing regional adiposity using WHtR, WHR and waist circumference respectively. Among females, WHtR, WHR and waist circumference respectively showed 9.53 times, 3.96 times and 6.00 times higher risk of regional adiposity with irregular pattern of physical activity. General and regional adiposity measures also showed positive correlation with triglycerides and negative correlation with HDL which are an important variables for the estimation of cardio vascular problems. Similar findings were also found by Fogelholm (2009) and Dijk et al (2012). Among irregular physical activity males, increase in risk of triglycerides level was 9.10 times more compared to regular activity males.

The regional distribution pattern of fat, which is as important indicator of cardio vascular and metabolic disorders particularly diabetes mellitus (Lapidus et al, 1984; Ohlson, 1988; Bouchard et al, 1990) as compared to total body fat, was studied with the help of regional fat distribution indices- WHR WHtR and WC. WHR is used to differentiate the distribution of body fat on the lower and upper body. It was introduced as a simple index of body fat distribution (Hartz et al, 1980) and it was subsequently found to be a more sensitive index of metabolic abnormalities in the obese than the use of neck, bust, waist or hip circumference measurements alone (Ashwell et al, 1985; Hartz et al, 1983; Birmingham et al, 1999). All the mean values showed higher risk of central and general adiposity markers among adult males and females who were involved in irregular pattern of physical activity or had sedentary life style.
An elevated waist/hip circumference ratio, which may indicate central adiposity, has been shown to correlate with the presence of hypercholesterolemia, diabetes and coronary artery disease, independent of BMI, and may predict the complications of obesity in adults better than BMI does (Odom, 2006).

The lower body fat predominance, gynodial fat deposits, is reflected by lower values of the WHR and upper body fat predominance, androidal fat deposits, by the higher values of WHR (Hartz et al, 1984). WHR that exceed 0.80 for women and 0.95 for men are associated with an increased risk of death from coronary artery disease as well as variety of illness, most notably type II diabetes, hypertension and general overall mortality (McArdle et al, 1994). This may be because of excess fat in the abdominal area (central or android type obesity, most prevalent in males) is more active metabolically and thus more active in processes related to heart disease than fat located on the hips and thighs. General obesity assessed from body mass index (BMI) and grand mean thickness (GMT) showed that Punjabi males and females with irregular pattern of physical activity were not only overall fatter but their trunkal fat (WHR and WHtR) was also higher compared to sedentary group followed by regular activity group. The groups with higher values of general and regional fat were more disposed to cardiovascular and metabolic health problem also showed higher blood pressure, blood sugar, triglycerides and waist circumference and lower HDL.

Human physiology is the science of the mechanical, physical and biochemical functions of human in good health, their organs and the cells of which they are composed. Physiological functions and different body measurements are highly related. It is affected by altitude, ethnic variation and physical activity etc (Kapoor and Kapoor, 2005). Our lifestyle has changed faster than our genetically programmed metabolism.

To study the physiological functions of adult Delhi population, blood pressure, heart rate, pulse rate, grip strength, VO\textsubscript{2max}, fasting blood sugar and haemoglobin were studied. Among human beings the maximum biological adaptability to any environmental stress is provided by physiological functions especially among adults. The deviation from the normal range in various physiological variables indicates the physical health status of the person. To find out cardiovascular fitness, blood pressure, heart rate, pulse rate,
oxygen consumption, basal metabolic rate were studied among adult Punjabi males and females of Delhi.

Blood pressure or hypertension in particular is a complex traits in which the clinically defined phenotype may arise through a wide array of pathological mechanism. Several environmental variables have been identified that are associated with blood pressure. These include excessive weight/obesity, sodium intake and levels of physical activity, food habits, alcoholic intake and smoking habit etc (Ward, 1990).

It is well known that the blood pressure is influenced by a large number of external factors. Body composition, habitual physical activity, diet, income, smoking and alcohol consumption are various factors responsible for high blood pressure. The result of present study indicated that higher mean values of systolic and diastolic blood pressure were found among sedentary group of males and females, followed by irregular active group and regular active group. Barengo et al (2004) reported the moderate to vigorous intensity physical activity to be associated with lower incidence of hypertension.

Hypertension was found to be more prevalent among adult Punjabi males and females with irregular pattern of physical activity (67.4% & 50.0% respectively) as compared to their counterpart regular physical activity group (61.1% & 36.5% respectively). The higher percentage of hypertension among adult males as compared to females is noteworthy. Similar findings have been previously reported in Jamaicans (Ferfuson et al, 2008). The higher percentage of hypertension among the present subjects may be attributable to irregular pattern of physical activity, in dietary habits preference of non vegetarian food, more fried food, higher level of general and regional obesity, lower education level and more involvement in self employed business. The comparatively lower percentage of hypertension among adult Punjabi females could be attributable to a protective effect of estrogen (Mendelson & Karas, 1999), since most of the women were pre menopausal and non smokers. The lower level of hypertension among females can also be because of the compounding effect of essential fats. Avoiding a sedentary lifestyle during adulthood not only prevent cardiovascular disease independently of other risk factors but also substantially expands the total life expectancy (Oscar et al, 2005).
Mean heart rate and pulse rate among adult Punjabi females were slightly higher than their male counterparts as was also reported in earlier studies (Singh et al, 1999; Palatini, 1999, Tandon, 2006; Mungreiphy, 2009). This difference is largely accounted for by the size of the heart, which is typically smaller in females than males. The smaller female heart, pumping less blood with each beat, needs to beat at a faster rate to match the larger male heart's output (Huxley, 2007). Males and females with sedentary life style showed higher mean values followed by irregular activity group and regular activity group. Resting heart rate (RHR) is one of the simplest cardiovascular parameters, which usually averages 60 to 80 beats per minute (bpm), but can occasionally exceed 100 bpm in unconditioned, sedentary individuals and be as low as 30 bpm in highly trained endurance athletes. Epidemiological evidences demonstrate that RHR, or its corollaries, namely post exercise heart rate recovery, which is mediated primarily by vagal tone, and heart rate variability correlates with cardiovascular morbidity and suggests that RHR determines life expectancy (Cook et al, 2006). Rates below 60 bpm referred to as bradycardia and rates above 100 bpm referred to as tachycardia. Heart rate proves to be the best predictor after myocardial infarction (Disegni et al, 1995; Hathaway et al, 1998), in patients with congestive heart failure, as well as in patients with diabetes mellitus or hypertension.

Grip strength, a measure of muscular strength was higher among males when compared to females. Regular activity males and females showed higher mean values of muscular strength compared to irregular activity group and sedentary group. Better performance of males in hand grip strength than females is because males are endowed with more muscle mass and females more fat mass (Forbes, 1987). Grip strength was negatively associated with fasting blood sugar in the present study. The studies reported that Sarcopenia, the loss of muscle mass and strength, is significantly associated with symptoms of metabolic syndrome as well as insulin resistance. Both sarcopenia and insulin-resistant states shared common cellular and molecular changes. Like, both are associated with the accumulation of myofibre lipids (Janssen & Ross, 2005; Furler et al, 2001) which may affect the insulin-signalling pathway (Shulman, 2000). The link between impaired mechanical and metabolic function may extend to other important
insulin resistant glucose intolerant states, such as central obesity and the metabolic syndrome (Sayer et al, 2007).

**Social and lifestyle factors**

**Socio economic status (SES)** is a rank or position of a person in society and is often measured by income, education and profession. The socioeconomic indicators are associated with lifestyle health problems. It was found that higher education level and job as a profession leads to active life style while lower education level and self employed individual are more sedentary in their life style pattern. This sedentary behavior corresponds to the increasing prevalence of symptoms of metabolic syndrome and adiposity risk among them. Low nutrition knowledge (Shepherd et al, 2006) and lower education (Rosmond et al, 1999) could be barriers to choosing a nourishing diet. Lack of time is an obstacle both for healthy eating and physical activity (Jenkins & Horner, 2005; King et al, 2000). The present study subjects who were self employed or homemaker, as a result were not bound by any fixed routine of work which may make them relatively sedentary. Education may protect against disease by influencing life style behaviors, problem solving activities and values (Liberatos et al, 1988). The result in the present study was consistent with other studies mentioned above.

**Education** Irregular active group and sedentary group of males and females were less educated compared to the regular active group. It could be that education may protect against disease by influencing life style and better time management (Liberatos et al, 1988). It could be other way round, that increase in the level of education caused a shift from manual work to more sedentary and knowledge based work (Gupta, 2010). Many studies have reported negative association between level of education and hypertension (Kennedy et al, 1998; Mendez et al, 2002; Williams, 2010) which arises with the present study results. Whereas, studies showed positive correlation between education and obesity (Agarwal, 2002; Mungreiphy, 2009; Gupta, 2010), which was varying in the present study. This could be due to the reason that increases in education, increases the level of knowledge based work, which may lead to stress and tension. The think job involves sitting around causing overweight/ obesity, an important risk factor for higher blood pressure.
**Occupation** has important impact on life style pattern among adult Punjabi males and females of Delhi. Among males, sedentary and irregular physical activity group were self employed while regular physical activity group were mostly in jobs (Govt or private). In regular physical activity group, more percentage of females was in service compared to the other two groups. Majority of sedentary and irregular activity females were homemakers, and this difference was also reflected in their biological attributes like blood pressure, blood sugar, adiposity markers and respiratory functions.

**Family type** Among adult Punjabi males and females, maximum number of subjects in both physically active and sedentary group were found to be living in joint families. Census 2011 data reveals that number of households with joint families has gone up by 77% in the suburban areas since a decade ago.

More than half of the active males and females were in joint family and majority was in service sector. It may be because members used to help each other in their work and they were able to maintain an active life and better discipline. They have systematic schedule for a day which they have to follow because of their busy timetable. On the other hand, among sedentary group, 64.2% males and 68.4% females also lived in joint family. But they were more involved in self employed occupation or preferred to spend more time in home and had low education level. They don’t have to report in office at specific time and can go to office at any time or maybe they can spend their whole day in their house. They were inclined to spend their life lavishly without doing any leisure time activity. They had no worries of losing their jobs because they had their own business and a secure position in the society.

Over the last several decades, marked changes have occurred in the family structure in many societies by various factors, such as migration, economic fluctuations and instability. The World Health Organization (WHO) defines health determinant as “the range of personal, social, economic and environmental factors which determine the health status of individual or population’ (WHO, 1998). Therefore, family composition is regarded as a health determinant in our social environment. Health and well being of an individual are mainly the result of synergistic interactions among number of determining factor.
There are concerns that how changes in family structures influence the health and well being and quality of health outcome of the population. Previous studies have indicated association of large family composition and health behaviors in different communities (Ferrer & Burge, 2005). There are concerns regarding the further influence of multigenerational family composition on measure of health status and quality of life.

**Television (TV)** viewing represents a major sedentary behavior which has been associated with physical fitness (Tucker, 1990). Reduced levels of physical activity during TV watching may lead to a lower energy expenditure and lower lean body mass, thus affecting resting metabolic rate (RMR) and total energy expenditure.

Higher percentage of sedentary group males and females preferred to watch TV for more than 4 hours a day while those who were irregular in their physical activity mostly watched TV for 2-4 hours. Regular activity group of males and females like to watch TV for 1-2 hours or less than an hour a day. They preferred to spend their leisure time in reading and other activities when compared with the counterparts of sedentary group of males and females. The TV watching induces unnecessary snacking and make the individual more lethargic. More hours of TV watching in a day may leads to sedentary lifestyle and irregularity of physical activity which also increased the risk of higher BMI, fat percentage, central obesity, high blood pressure, high blood sugar and higher values of lipid profile among adult Punjabi males and females of Delhi.

**Hours of sleeping** Chaput et al (2009) indicated that industrialization and computerization has led to reduction in sleep time and an increase in knowledge based work (KBW) both of which exert trivial effect on energy expenditure thus considered as sedentary activity. However their respective effect on energy intake is opposite. An increase in the practice of the most sedentary activity, i.e. sleep, is associated with a hormonal profile facilitating appetite control whereas KBW apperas as a stimulus favoring a significant enhancing effect on food intake.

In the present study, the proportion of the subject who slept for 6-8 hours a day was found to be 66.8% and 68.2% in active and sedentary group respectively. Higher percentage of sedentary group (22.7%) slept for more than 8 hours per day as compared to active group (13.0%). Females who slept for more than 8 hours a day had higher chances of being irregularly active (4.14 times) or sedntary (4.99 times).
Discussion

Sleep deprivation is associated with increased activity in the sympathetic nervous system, which controls the body’s stress response. Over time, activation could contribute to high blood pressure. Kristen et al (2009) reported that middle aged adults who slept for fewer hours appeared more likely to have high blood pressure and to experience adverse changes in blood pressure over time. Each hour of reduction in sleep duration was associated with a 37 percent increase in the odds of developing high blood pressure.

Eating pattern Since diet has far reaching influence on health, it was essential to have idea of dietary pattern of the present population. Self reported information on dietary habit was collected to assess the general food habit and to find out the association of the pattern of physical activity. Most of the regular group of physical activity were vegetarian. They had their breakfast regularly. Males who skipped their breakfast had higher chance of following sedentary lifestyle. Males and females who had their breakfast on irregular basis also had higher chance of becoming sedentary.

Various lifestyle factors affecting pattern of physical activity has been summarised in table 4.1.

Table 4.1 Lifestyle factors affecting pattern of physical activity

| Lifestyle factors | Males | | | | Females | | | |
|------------------|-------| | | | | | | |
|                  | Irregular PA | Sedentary group | | Irregular PA | Sedentary group | |
| TV watching      |       | | | | | | |
| More than 4 hrs/day | 17.84** | (2.16-147.36) | 6.47 | (0.54-77.92) | 1.17 | (0.45-3.03) | 9.70*** | (3.37-27.93) |
| 2-4 hrs/day      | 1.23 | (0.54-2.80) | 4.06*** | (1.79-9.20) | 1.57 | (0.67-3.71) | 3.58* | (1.22-10.49) |
| Sleep per day    |       | | | | | | |
| More than 8 hrs/day | 0.77 | (0.24-2.50) | 0.81 | (0.25-2.62) | 4.14** | (1.51-11.37) | 4.99** | (1.65-15.13) |
| Breakfast        |       | | | | | | |
| Absent           | 8.33  | (0.91-76.47) | 15.89** | (1.71-147.92) | 1.23 | (0.37-4.00) | 1.77 | (0.47-6.65) |
| Irregular        | 0.40  | (0.10-1.49) | 2.69* | (1.03-7.02) | 2.26 | (0.85-6.01) | 6.794*** | (2.24-20.57) |

*p<0.05, **p<0.01, ***p<0.001
It was found that TV watching more than 4 hours a day or 2-4 hours a day as well as irregularity or absence of breakfast were more likely to follow irregular pattern of physical activity and sedentary lifestyle when compared to those who watched TV for less than 2 hours a day and had regular breakfast respectively. Among females who slept more than eight hours a day were significantly likely to become irregular in their physical activity or sedentary. It may conclude that lifestyle factors play major role in adopting different patterns of physical activity and the associated health problems or benefits.

**Energy consumption and pattern of physical activity**

Divergent to physical activity is sedentary behavior. Sedentary behavior is defined as engagement in pursuits that require expending low amounts of energy, equivalent to less sleeping but more sitting (Biddle, 2007). It is not merely absence of moderate or vigorous physical activity. Sedentary behavior can coexists with physical activity. It may draw interest as an independent health risk factor (Healy et al, 2008a).

Basal metabolic rate (BMR) using Tanita body composition analyzer and basal energy expenditure (BEE) using Benedict’s equation were evaluated. Both the values of BMR and BEE showed significant correlation which provides validation for the same. It was found that mean values of BMR and oxygen consumption was higher among males and females with regular physical activity pattern compared to irregular physical activity pattern group. This could be because due to regular interruption in their physical activity levels, their metabolic rate also increase and decrease. This in combination with consistent eating pattern may at interval cause positive energy balance, leading to obesity and hence more and more of metabolically less active tissue causing further decrease in metabolic rate and consequently gain in fat mass. The other factor could be that the subjects with irregular pattern of physical activity may tend to eat more under the false impression of doing physical activity.

**Lung functions and respiratory efficiency**

Many studies have emphasized that respiratory functions are mainly governed by environmental factors and level of habitual physical activity (Cotes et al, 1973; Brown
& Jones, 1977; Kapoor & Kapoor 2005). Lung functions also varies due to the physical
activity levels (Jain & Ramiah, 1968; Chatterjee & Mondal, 1991) nutritional, socio
economic factors (Bhattacharya & Banerjee, 1966) and environmental and genetic
factors (Patric & Patel, 1986).

All the lung functions were found to be higher among adult males and females who
were regular in their physical activity indicating a better respiratory efficiency
compared to the irregular physical activity group. Garcia-Aymerich et al (2006) found
that those who were suffering from chronic obstructive pulmonary disease (COPD) and
performed some level of regular physical activity had lower risk of COPD and
mortality. The biological plausibility of the influence of physical activity on the decline
of lung function relies on the anti-inflammatory effects of physical activity, which have
been described in experimental studies (Das, 2004). Regular physical activity
suppresses the production of inflammatory markers (IL-6, TNF-α, CRP) and
intracellular adhesion molecule; enhances the anti-inflammatory markers (TGF- α, ILO-
4, IL-10) and adiponectin; and stimulates the synthesis of endothelial nitric acid (eNO),
prostacyclin from the vascular endothelial cells, and tissue manganese superoxide
dismutase (Clarkson and Thompson, 2000; Das, 2004). A recommendation to maintain
or increase the levels of regular physical activity should be considered in future health
guidelines, which may play a significant role in public health benefits.

There has been higher mean values of all the lung functions namely, forced expiratory
volume in first second (FEV$_{1.0}$), forced vital capacity (FVC), peak expiratory flow rate
(PEFR) among regular physical activity Punjabi males and females. The normal range
of forced expiratory ratio (FER) in all the subjects is indicative of absence of obstructive
airway problem. It was observed that sedentary group of males had lowest values as
compared to irregular and regular activity group with respect to respiratory functions.
While among females, irregular activity group showed lowest values of respiration
functions and they also had 2.45 times higher risk of obstructive airway problems as
compared to regular activity group using FER. Shinohara et al (1997), found that
respiratory function, are linked to the magnitude of obesity as well as to the presence of
abdominal fat. Destruction of the pulmonary functions is directly related to abdominal
obesity due to decrease physical activity.
The present study subjects involved in irregular pattern of physical activity and sedentary lifestyle showed lower mean values of respiratory functions along with chest expansivity (CE) and breath holding time (BHT). Glucose metabolism also affects respiratory functions (Wendy et al, 2004; Tricia et al, 2005) as it was found in present study also that fasting blood sugar showed inverse relationship with respiratory functions among males and females. Larger the waist circumference lesser the pulmonary function, may be due to an increase in abdominal fat deposition, thoracic volume reduces consequently. Socio economic status also affect the respiratory efficiency. Studies were found that lower education level may increase the risk of respiratory problems (Wijnhoven et al, 2001; Hesselink et al, 2006) which was found to be consistent with the present study findings also.

**Lipid profile and physical activity**

Physical activity has long been associated with reduced risk of coronary heart disease (CHD). Lipid and lipoprotein abnormalities play a major role in the development and progression of coronary artery disease. The protective role of physical activity on cardiovascular morbidity has, mainly, attributed to its favourable effects on several "traditional" coronary risk factors, like body composition, arterial blood pressures as well as to inflammation process (Sesso et al, 2000). On the other hand, the influence of physical activity on lipids levels showed conflicting results in the few large population studies that have evaluated this association (Wilson et al, 1988).

Variables for lipid profile i.e. total cholesterol (TC), high density lipoprotein (HDL), triglycerides, low density lipoprotein (LDL) and ratio of total cholesterol and HDL, were found to have statistically higher mean values among irregular physical activity group as compared to regular activity group except high density lipoprotein (HDL) in males. Males with irregular pattern of physical activity showed 9.10 times higher risk of increasing triglycerides level when compared with their counterpart regular activity group. The present study result agrees with the finding of Wilson et al (1988) who concluded that regular exercise group have a more favourable lipid profile than those who do not exercise. This may be translated to a reduction in the risk for developing atherosclerosis.
Using Framingham scale, the present study showed higher percentage of risk was found among males and females with irregular pattern of physical activity as compared to those who were regular in their physical activity. Framingham study showed men and women that reported having a sedentary lifestyle were at a substantially higher risk of developing CHD compared to active participants (Wagner et al, 2002).

**Genetic basis of metabolic syndrome and obesity**

**Genes and environment**

The prevalence of the metabolic syndrome in some developing countries approaches those seen in developed regions. With ongoing demographic changes and an aging population, the impact of the metabolic syndrome will be significantly greater in the developing countries. The causes of the metabolic syndrome are likely to reflect a mix of genetic and environmental factors and the interactions between these. Recent studies confirm that genetic factors contribute to the concentration of the metabolic syndrome and its components within family groups (Mohan et al, 2001).

Despite being long recognized as a major global health, social and economic problem, the obesity epidemic is continuing without signs of abatement (James 2008; Frühbeck 2008). Noteworthy, the rate of increase in the prevalence of obesity appears to be steepening in many parts of the world, which suggests that our lifestyle is becoming even more obesogenic.

Obesity is the result of hugely variable and complicated interactions between an individual’s genetic background and the immediate environment, which are all heavily influenced by numerous social and cultural cues. Beyond that view, in purely energetic
Discussion

terms, obesity holds little mystery as it simply represents the excess of energy intake over expenditure. In this context, the development of obesity depends not only on the net outcome between food intake and energy expenditure but also on the balance between different fat stores. The association of various adiposity markers and CVD variables with variants of UCP 1 among the present subjects revealed the association to be marked among females but not so among males. Besides, gender differences in the pathway followed by this gene, it may be true that wild type or mutant form may independently control obesity and blood pressure.

Potential therapeutic approaches for human obesity treatment

Uncoupling protein 1 (UCP 1) has been suggested as an obesity gene in humans. It is a proton transporter which uncouples oxidative metabolism from ATP synthesis and dissipates energy through the heat (Garlid et al, 1996). It is expressed exclusively in the inner mitochondrial membrane of brown adipose tissue and acts by uncoupling substrate efficiency (Nicholls & Locke, 1984). Brown adipose tissue plays an important part in the regulation of energy expenditure while brown adipose tissue (BAT) dysfunction develop obesity (Lowell et al, 1993).

Plausible BAT-oriented strategies to combat obesity aimed at increasing energy expenditure might be in two ways: first, to stimulate the activity of already existing BAT and, second, to favor the occurrence of brown adipocytes by inducing the specific gene expression programme of brown fat cells via specific molecular switches. Elucidation of the regulation of these specific pathways could facilitate the design of modulating agents with potential scope for effective therapeutic manipulation.

Obesity as a complex syndrome with a multifactorial origin may be explained in some circumstances by monogenic mutations, but in most cases appears as a polygenic condition, which may be additionally affected by a myriad of environmental influences (Bray & Bouchard, 2004; Froguel & Boutin; 2001). A widely accepted hypothesis assumes that complex diseases such as obesity are likely to be based on a limited number of predisposing alleles, each conferring a small increase in the risk to the individual. Heterogeneity in complex phenotypes implies that the genetic predisposition may also result from any one of several rare variants in a number of genes (Swarbrick
Discussion

& Vaisse, 2003). The role of a genetic predisposition in obesity has long been assumed to affect both energy intake and energy expenditure equation (Loktionov, 2003).

So for the clearer depiction of gene environment interaction, uncoupling protein 1 was studied in the present study. Detailed discussion of the above topic is given in results under objective 9.

In order to see the transition in obesity levels, both general and regional with time, lifestyle, SES, a comparison of present study result was made with some other studies. A comparison of general adiposity markers with previous studies among adult males and females (Table 4.2) was made from 1978 to 2012.

Table 4.2 Comparison of general adiposity markers

<table>
<thead>
<tr>
<th>Year</th>
<th>Males BMI</th>
<th>Males GMT</th>
<th>Males Fat%</th>
<th>Females BMI</th>
<th>Females GMT</th>
<th>Females Fat%</th>
<th>Age group (years)</th>
<th>Population</th>
<th>Area</th>
<th>Investigators</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>27.6</td>
<td>17.1</td>
<td>25.3</td>
<td>28.2</td>
<td>20.7</td>
<td>34.7</td>
<td>30-60</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Present study</td>
</tr>
<tr>
<td>2012</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>22.8</td>
<td>-</td>
<td>-</td>
<td>20-60</td>
<td>Zou tribe</td>
<td>Manipur</td>
<td>Tungdim</td>
</tr>
<tr>
<td>2011</td>
<td>25.9</td>
<td>19.1</td>
<td>23.2</td>
<td>27.7</td>
<td>27.0</td>
<td>34.5</td>
<td>35-65</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Kapoor</td>
</tr>
<tr>
<td>2010</td>
<td>26.1</td>
<td>22.9</td>
<td>-</td>
<td>29.4</td>
<td>32.0</td>
<td>-</td>
<td>31-50</td>
<td>Baniya</td>
<td>Delhi</td>
<td>Gupta</td>
</tr>
<tr>
<td>2009</td>
<td>20.9</td>
<td>7.8</td>
<td>-</td>
<td>21.2</td>
<td>10.7</td>
<td>-</td>
<td>20-70</td>
<td>Tangkhul Naga</td>
<td>Manipur</td>
<td>Mungreiphy</td>
</tr>
<tr>
<td>2007</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20.1</td>
<td>8.9</td>
<td>-</td>
<td>45-55</td>
<td>Rajputs</td>
<td>Utranchal</td>
<td>Mungreiphy et al</td>
</tr>
<tr>
<td>2006</td>
<td>26.9</td>
<td>14.0</td>
<td>-</td>
<td>27.6</td>
<td>17.9</td>
<td>-</td>
<td>31-60</td>
<td>Punjabi Khatri</td>
<td>Delhi</td>
<td>Tandon</td>
</tr>
<tr>
<td>2001</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20.1</td>
<td>11.6</td>
<td>-</td>
<td>18-36</td>
<td>Punjabi Arora</td>
<td>Delhi</td>
<td>Khanna</td>
</tr>
<tr>
<td>2000</td>
<td>19.8</td>
<td>8.33</td>
<td>-</td>
<td>20.9</td>
<td>13.3</td>
<td>-</td>
<td>20-24</td>
<td>General</td>
<td>Delhi</td>
<td>Tyagi</td>
</tr>
<tr>
<td>1991</td>
<td>25.2</td>
<td>-</td>
<td>-</td>
<td>27.6</td>
<td>-</td>
<td>-</td>
<td>30-59</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Verma</td>
</tr>
<tr>
<td>1978</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>19.6</td>
<td>15.7</td>
<td>18.8</td>
<td>16-32</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Satwanti</td>
</tr>
</tbody>
</table>

A clear increasing trend from 1978 to 2012 in general adiposity markers using BMI, GMT and fat percentage, has been noticed among adult males and females. Exception was seen among Tangkhul Naga of Manipur and Rajputs of Utranchal which could be attributed to different environment and its related stresses besides variation in ethnicity. Higher mean value of GMT among males (22.9 mm) and females (32.0 mm) of Baniya and BMI (29.4 kg/m²) among Baniya females of Delhi reflects their sedentary life style pattern and higher socio economic status besides different ethnicity. Among Punjabi females of Delhi, marked increase in adiposity markers was noticed - 8.6 kg/m² in BMI, 5 mm in GMT and 15.9% in fat percentage- over a period of 34 years.
A comparison of regional adiposity markers (Table 4.3) with previous studies among adult males and females was made from 1978 till 2012. An increasing trend in all the indices like WC, WHR and WHtR was clearly evidenced from 1978 to 2012 among adult males and females. Lower mean values were seen among Tangkhul Naga of Manipur and Rajputs of Uttranchal, attributed to difference in environment, ethnicity and habitual physical activity.

Table 4.3 Comparison of regional adiposity markers

<table>
<thead>
<tr>
<th>Year</th>
<th>Males</th>
<th></th>
<th></th>
<th>Females</th>
<th></th>
<th></th>
<th>Age group (years)</th>
<th>Population</th>
<th>Area</th>
<th>Investigators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WC</td>
<td>WHR</td>
<td>WHtR</td>
<td>WC</td>
<td>WHR</td>
<td>WHtR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>93.5</td>
<td>0.93</td>
<td>0.55</td>
<td>84.5</td>
<td>0.82</td>
<td>0.55</td>
<td>30-60</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Present study</td>
</tr>
<tr>
<td>2012</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>80.8</td>
<td>0.89</td>
<td>0.54</td>
<td>20-60</td>
<td>Zou tribe</td>
<td>Manipur</td>
<td>Tungdim</td>
</tr>
<tr>
<td>2011</td>
<td>85.3</td>
<td>0.90</td>
<td>0.51</td>
<td>83.7</td>
<td>0.80</td>
<td>0.54</td>
<td>35-65</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Kapoor</td>
</tr>
<tr>
<td>2010</td>
<td>98.3</td>
<td>1.00</td>
<td>0.59</td>
<td>92.0</td>
<td>0.86</td>
<td>0.60</td>
<td>31-50</td>
<td>Baniya</td>
<td>Delhi</td>
<td>Gupta</td>
</tr>
<tr>
<td>2009</td>
<td>76.6</td>
<td>0.88</td>
<td>0.47</td>
<td>76.8</td>
<td>0.87</td>
<td>0.51</td>
<td>20-70</td>
<td>Tangkhul naga</td>
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<td>Mungreiphy</td>
</tr>
<tr>
<td>2007</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>69.6</td>
<td>0.80</td>
<td>-</td>
<td>45-55</td>
<td>Rajputs</td>
<td>Uttranchal</td>
<td>Mungreiphy et al</td>
</tr>
<tr>
<td>2006</td>
<td>91.3</td>
<td>0.93</td>
<td>-</td>
<td>85.0</td>
<td>0.87</td>
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<td>31-60</td>
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<td>Tandon</td>
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<tr>
<td>2001</td>
<td>-</td>
<td>-</td>
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<td>69.8</td>
<td>-</td>
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<td>18-36</td>
<td>Punjabi Arora</td>
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<td>Khanna</td>
</tr>
<tr>
<td>2000</td>
<td>72.4</td>
<td>0.85</td>
<td>-</td>
<td>69.5</td>
<td>0.77</td>
<td>-</td>
<td>20-24</td>
<td>General</td>
<td>Delhi</td>
<td>Tyagi</td>
</tr>
<tr>
<td>1991</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>30-59</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Verma</td>
</tr>
<tr>
<td>1978</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>63.9</td>
<td>0.72</td>
<td>0.41</td>
<td>16-32</td>
<td>Punjabi</td>
<td>Delhi</td>
<td>Satwanti</td>
</tr>
</tbody>
</table>

Among females, marked increase in regional adiposity markers was noticed - for WC an increase of 20.6 cm, WHR an increase of 0.10, and WHtR an increase of 0.14 - over a period of 34 years. Males also exhibited similar trend. The synergy that our lifestyle type has changed faster than our genetically programmed metabolism seems to be proved by the comparison.