DISCUSSION

India is a vast country with an enormously variable population. There are large differences in geographical, environmental, ethnic, religious, cultural and socioeconomic parameters in different population groups which affect the human health and disease occurrence. Prevalence of respiratory diseases especially asthma is increasing at an alarming rate. In the present investigation an attempt has been made to study anthropometric profile and pulmonary functions of bronchial asthma patients of Hoshiarpur district of Punjab (India). Observations related to anthropometric measurements and pulmonary functions have been discussed under the following headings.

I. Anthropometric Profile

   i) Anthropometric measurements

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I. Anthropometric Profile

i) Anthropometric measurements

a) Weight

Body weight is one of the most important physical characteristics at all ages and is considered to be the chief trait to change during adult life. It gives an important indication about health status of a person.

In the present study, patients have been found to be lighter in weight than controls in all the age groups with statistically significant differences at the age groups of 40-49, 60-69 and 70+ years in males and 40-49, 50-59 and 60-69 years in females (Table 3 and fig.1). The mean weight of the total sample in the patient and control males has been found to be 58.12 kg and 66.04 kg respectively and in patient and control females, it has been found to be 55.36 kg and 63.79 kg respectively. The differences in
the mean weight of patients and controls are statistically significant in both males and females (Table 52a and 52b). Chen et al. (1993) have reported that body weight provides an alternative index of lung size. Chronic respiratory disorders have shown a U-shaped relation to measures of body weight, since their prevalence is elevated in both under- and over-weight individuals.

Majority of the asthmatic subjects (63.52%) in the present study were from rural areas (Table 2). Therefore several environmental factors like poor housing conditions, dust mites, dust allergy, poor diet, stress of living with this chronic disease, poor access to health care services and poor disease control might have contributed to their lower weight in the present study. Hoshiarpur is also a small city and asthmatic patients from villages nearby to Hoshiarpur seek healthcare in the main city as there are no facilities of specialist doctors in rural areas. In India, overweight and obesity are more prevalent among affluent persons living in large cities and underweight more frequent in urban slums and rural populations (WHO Expert Committee, 1995 and International Institute of Populations Sciences, 2000).

Rastogi et al. (1991) and Fernandez & Mesquita (1995) have reported that unfavourable occupations in rural areas especially stone crushing increase the risk of asthma. The other major causative agents reported are pollen grains, fungal spores, insect debris and animal epithelia etc. (Singh & Kumar, 2003). Ramanakumar & Aparajita
(2005) have also reported that bronchial asthma has been recorded as leading cause of
death in rural India.

Wright & Fisher in 2003 have reported that like most of the diseases, asthma also
is socially patterned with lower socioeconomic group on average being more burdened.
As Weiss & Wegener (1990) and O’ Neil et al. (2003) have also reported that there is
increased exposure to adverse environmental factors among lower socioeconomic groups
which is responsible for causing asthma. Philips Unveils India Health and Wellbeing
Index Report (2011) also revealed that 12% of the respondents in rural India while only
2% of urban India are worried about asthma. The data on morbidity by type of diseases
/ailments state that bronchial asthma has emerged as one of the top six ranking diseases

b) Linear measurements

The genetic and environmental factors influence height. Social conditions are
important among environmental factors, and height is partly a surrogate marker for
conditions in early life (Rona et al., 1978; Rona, 1981; Marmot et al., 1984; Arnesen et
al., 1985; Kuh et al., 1991 and Sorenset et al., 1999). To a lay man height seems to be
stable after its adult values are attained, but it is not as stable as it seems to be. It
increases, although to a very minor extent between twenties and thirties and then
decreases as the individual ages (Singal & Sidhu, 1981a). Gender and height are the most
important predictors of pulmonary functions. Stature is positively correlated with lung
size usually to a greater extent than any other anthropometric index and is the reference variable of choice for most purposes. In addition, the sitting height is also informative. For most indices of lung function the best reference variables are the sex, age, stature and ethnic group (American Thoracic Society, 1991).

In the present sample of bronchial asthma patients and controls, stature has shown a trend of decrease with advancing age and the differences in the stature of the two groups are not statistically significant except at the age group 30-39 years in males. (Table 4 and Fig.2). A similar trend of decrease in stature has been reported by Himes & Mueller (1977) and Singal & Sidhu (1981b).

Sitting height seems to play a major role in shrinkage of stature. Trend of decline has been observed in sitting height of both patients and controls. The shortening of trunk region is attributed to the degenerative changes in the spine. The changes in intervertebral discs follow a definite chronological order, the weakening of which becomes statistically significant after the third decade (Ritchie & Fahran, 1976 and Lewin et al., 1971). Ericksen (1978) reported a significant trend towards lowering and broadening with age of the five lumbar vertebrae. Sitting height of patients and controls did not differ significantly except at the age group 30-39 years in males (Table 5 and Fig.3). In both patients and controls, stature and sitting height are positively correlated although the correlation is weak with most of the pulmonary variables and with lung age the correlation is negative (Table 54-57).
The subischial length has not shown any consistent trend in both patients and controls and the differences between patients and controls are not statistically significant (Table 6 and Fig. 4). A minor decrease in subischial length may be attributed mainly to secular factors, as many investigators have reported an increase of average adult stature during the last 100 years (Tanner, 1962 and Meredith, 1976). But bowed legs, burden of weight bearing and flat feet with ageing are some other factors responsible for decrease in subischial length (Himes & Mueller, 1977).

c) Circumferences

The measurements of upper arm circumference have long been known to reflect changes in adult body weight (Ohlson et al., 1956). It is also relatively independent of height (Olukoya, 1990). Like weight upper arm circumference has shown a trend of increase up to middle years followed by decrease in both patients and controls. Patients have lower values of upper arm circumference in most of the age groups with statistically significant differences at the age groups 30-39, 40-49 and 60-69 years in males and 30-39 and 50-59 years in females (Table 10 and Fig. 8). Singal & Sidhu (1983) also reported that circumferences i.e. upper arm and calf have followed a similar trend of increase and decrease as that of weight in females of two endogamous groups.

Other circumferences i.e. chest (taken only in males), waist and hip have shown a trend of increase up to 6th decade followed by decrease up to 70+ years. The patients have lower values of waist circumference in most of the age groups but not to the level of
significance (Table 8 and Fig. 6). The mean waist circumference is 82.05 cm and 82.69 cm in patient and control males respectively (Table 52a). In females, the mean waist circumference is 80.49 cm and 82.00 cm in patients and controls respectively and the differences is statistically insignificant (Table 52b). Whereas Del-Rio-Navarro et al. (2003) have reported that in women asthma associated with higher levels of waist circumference. Chen et al. (2005) also reported that women with WC > 100 cm had a significantly increased risk of asthma.

Hip circumference also did not show any statistically significant differences between patients and controls in all the age groups except 30-39 years in females (Table 9 and Fig. 7).

d) Chest width

The mean values of chest width in patients have been found to be lower in all the age groups than controls with statistically significant differences at the age groups 40-49 in males and 50-59, 60-69 years in females (Table 11 and Fig. 9). Behluli (1987) and Pavlica (1996) have reported that although the chest characteristics can help in assessing its volume but these variables do not correlate with the lung capacity to the highest possible extent.

e) Skinfolds

Skinfold thicknesses give a fair idea of body’s fat content. Four skinfolds i.e.
biceps, triceps, subscapular and suprailiac have been assessed. Like weight skinfolds have also followed a similar trend of increase up to middle years followed by decrease in both patients and controls. The skinfold value is lesser in patients with significant differences in some age groups. (Table 12 -15 and Fig. 10 -13). The mean values for all the four skinfolds are lesser in patients with significant differences except biceps skinfold (Table 52a and 52b).

ii) Body composition

Body composition is an important parameter for humans as it has been shown that either malnutrition or obesity, are correlated with overall morbidity and mortality (Heitmann et al., 2000). Body composition abnormalities are probably prevalent in all advanced respiratory disease but it is not routinely assessed when patients with respiratory disorders are evaluated. Measurement of body weight or BMI, however, does not accurately reflect changes in body composition in these patients. The prevalence of muscle atrophy in chronic respiratory diseases will be underestimated if body weight only is measured. The body weight can be divided in to fat mass and fat free mass. Therefore the study of body composition of these patients may reflect a better picture. The measurement of skinfold thicknesses at 4 sites i.e. the biceps, triceps, subscapular and suprailiac have been used to evaluate body fat and lean body mass.

In the present study, asthmatic patients have been found to possess significantly lower amount of body fat and lean body mass in most of the age groups as compared to
control subjects. The mean absolute body fat in patients and controls has been found to be 13.67 kg and 27.34 kg respectively in males and 19.18 kg and 22.81 kg respectively in females. Mean lean body mass in patients and controls is 44.39 kg and 50.85 kg respectively in males and 36.36 kg and 43.08 kg respectively in females. Patients have significantly lower values of body fat and lean body mass as compared to controls (Table 52a and 52b). Minas et al. (2010) have also reported that patients with severe refractory asthma have reduced amount of fat free mass. The coexistence of intense local and systemic inflammation may have lead to loss of fat free mass in patients with severe refractory asthma.

The distribution of body fat also plays an important role in lung functioning. The contours of the body undergo considerable changes from 20 to 70+ years due to differential rates of growth of the fat at different region of the body. Fatty depots tend to disappear from the periphery although bellies are bulging out with lot of fat deposition. These changes in fat distribution with age have been reported by various investigators (Glanville & Geerdink, 1970; Damon et al., 1972; Montoye et al., 1975; Bokan & Norris, 1927 and Singal & Sidhu, 1983). Skerlj et al. (1953) have reported an increase of internal body fat from about 30 years, though the subcutaneous fat remained same or decreased in the distal parts of the extremities. This redistribution of body fat and its increase during adult years might play an important role in the functioning of lungs as has been reported by various investigators. Central adiposity has pronounced association with lung function.
II. Pulmonary functions

Chronic respiratory disease is associated with increased mortality (Ebi-Kryston, 1988 and Mannino et al., 2003), but even mild perturbations in lung function, which may not be clinically apparent, have been shown to predict respiratory and all-cause mortality (Tockman & Comstock, 1989 and Schunemann et al., 2000). Pulmonary functions are generally determined by respiratory muscle strength, compliance of the thoracic cavity, airway resistance and elastic recoil of the lungs. It is well known that pulmonary functions may vary according to the physical characteristics such as age, height, body weight, and altitude (hypoxia or low ambient pressure).

In the present investigation spirometric evaluation of pulmonary functions has been carried out in both asthma patients and normal control subjects. Spirometric parameters evaluated in the present study are FVC, FEV1, and FEV1/FVC, FEF25-75%, PEFR, FEV3, FEV3/FVC and lung age.

a) Forced vital capacity (FVC)

In the present study forced vital capacity has shown a trend of decrease with advancing age in both patients and controls. The mean values of FVC are lower in patients with statistically significant differences in all the age groups except 20-29 years in males and 30-39 years in females (Table 22 and Fig. 26). The mean FVC among
patient and control males is 2.51L and 3.22 L respectively and in patient and control females is 1.86L and 2.25L respectively (Table 52a and 52b). Differences in the mean values have been found to be statistically significant. Decrease in forced vital capacity is more in patients which might be due to various changes in the airways due to asthma. Zeiger et al. (1999) and Habib (2009) have also reported decline in forced vital capacity in asthma patients.

b) **Forced expiratory volume in one second (FEV1)**

Forced expiratory volume in one second (FEV1) is a predictor of mortality in the general, as well as in the asthmatic population. Subjects with asthma have a steeper decline in FEV1 over time than subjects without. Moreover, a FEV1 lower than predicted is a marker of poor asthma control. The FEV1 is the most reproducible flow parameter and is especially useful in diagnosing and monitoring patients with obstructive pulmonary disorders (e.g. asthma, COPD). In the present study both patients and controls have shown a trend of decrease in FEV1 with advancing age. The mean values of FEV1 in both males and females in all the age groups have statistically significant differences with patients having lower values. The mean values of FEV1 in patient and control males are 1.37L and 2.42 L respectively and in patient and control females are 1.66L and 1.75L respectively and the differences in the mean values have been found to be statistically significant only in males (Table 52 a and 52 b). Fletcher and coworkers (1976) have also reported greater decline in FEV1 in men with asthma than in men without asthma. Ulrik et al. (1992) and Lange et al. (1998) evaluated FEV1 decline in large population samples
and reported that asthma has a significant impact on lung function decline. Burrows et al. (1987) reported decline in FEV1 of less than 5 ml per year in adults with asthma. In a study report of 25-year follow-up data on adults from a Dutch asthma clinic, more than 75 percent of the patients had FEV1 values below 90 percent of the predicted values at the final examination (Panhuysen et al., 1997). Zeiger et al. (1999) reported annual decline of 80.1 ml per year for FEV1 and 20.5 ml per year for FVC in the whole study group. Peat et al. (1987) found a mean loss of FEV1 in males suffering from asthma of about 50 ml/year as compared with 35 ml/year in normal subjects.

c) FEV1/FVC

Obstructive disorders are characterized by a reduction in airflow, particularly the FEV1 and the FEV1 expressed as a percentage of the FVC (FEV1/FVC). In patients with respiratory diseases, a low FEV1/FVC predicts morbidity and mortality (Mannino et al., 2003). FEV1/FVC ratio is decreased in asthmatic patients. In present study FEV1/FVC ratio has shown a trend of decrease with advancing age in both patients and controls. The FEV1/FVC values are significantly lower in patients as compared to controls (Table 24 and Fig. 22). The lower values in patients clearly indicate more reduction of airflow in patients.

d) Forced expiratory flow (FEF) 25-75%

The forced expiratory flow averaged over the time during which 25 to 75% (FEF 25-75%) of the FVC is exhaled is a sensitive marker of mild, small airway airflow limitation (Simon, 2010 and Ciprandi, 2011). FEF 25–75% gives an indication of what is
happening in the lower airways. It is a more sensitive parameter and not as reproducible as the others. It is a useful serial measurement because it will be affected before FEV1, so can act as an early warning sign of small airway disease. In small airway diseases such as asthma this value will be reduced, it could be more than 65% less than expected value.

In the present study forced expiratory flow 25-75% has shown a trend of decline in both patients and controls with increasing age. The difference in the mean values of FEF 25-75% among patients and controls have been found to be statistically significant in most of the age-groups with lower values and greater decline in patients (Table 25 and Fig. 23). Marseglia (2007) has reported reduced FEF25-75% with increasing severity of the allergic predictors.

e) Peak expiratory flow rate (PEFR)

For demonstrating the narrowing of airways, different expiratory flow rates are employed. Peak expiratory flow rate (PEFR) is one such parameter. The primary factors that affect PEFR are the strength of the expiratory muscles generating the force of contraction, the elastic recoil pressure of the lungs and the airway size. The PEFR is an accepted marker of pulmonary function and is widely used in respiratory medicine (Higgins, 1997).

PEFR has been found to decrease with age in both patients and controls. PEFR differed significantly among patients and controls with patients having lower values (Table 26 and Fig. 24). The mean PEFR values of patients and controls are 2.61 L/s and 4.77 L/s respectively in males and 1.92L/s and 3.39 L/s respectively in females with
statistically significant differences (Table 52a and 52b). Habib (2009) has also reported significant lower pulmonary function parameters including PEFR in asthmatic subjects as compared to healthy control group.

f) Forced expiratory volume in three seconds (FEV3)

Forced expiratory volume in three seconds is the volume of air which can be forcibly exhaled in three seconds. This volume usually is fairly close to the FVC since in the normal individual, most of the air in the lungs can be forcibly exhaled in three seconds. Like other pulmonary functions forced expiratory volume in three seconds has also shown decrease with advancing age in both patients and controls. Patients have lower values of FEV3 in all the age groups with significant differences except in age group 20-29 years (Table 27 and Fig. 25). Dykstra et al. (1999) and Ferguson et al. (2000) have also reported lower flow rates with ageing and disease which have been attributed to intrinsic airway changes and loss of lung elastic recoil leading to increased compression of the airways with forced expiration.

g) FEV3/FVC

FEV3/FVC is proposed to be a sensitive and more reliable index to identify early expiratory flow limitation when compared to FEF 25-75%. In the present study, there is consistent decline in FEV3/FVC with increasing age in both patients and controls. The differences in the mean values of ratio of FEV3/FVC among patients and controls are statistically significant in all the age groups except 20-29 years in males (Table 28 and Fig.26). Miller et al. (2005) also reported similar results.
h) Lung age

Recently, however, health care professionals have begun to express the results of pulmonary function tests as lung age instead of percentages. This idea is based on the fact that lung function declines with advancing age. This process begins in late 30’s. In addition to age asthma also affects lung age to a greater extent leading to more lung age in patients as compared to controls. In the present study asthmatic patients have been found to have poor lung health as compared to the healthy controls as reflected by their lung age. The mean lung age in asthmatic patients and controls is 77.59 years and 46.76 years respectively in males and 63.12 years and 45.23 years respectively in females with statistically significant differences (Table 52a and 52b).

Findings of the present study have shown that there is a greater decline in all the pulmonary function parameters in bronchial asthma patients as compared to controls in all the age groups. Asthma is a chronic inflammatory disease in which ongoing tissue injury and repair may result in irreversible fibrotic changes in the airways which has lead to decline in lung function. Reed (1999) also described asthma as a progressive disease leading to irreversible obstruction in the airways. Kupczyk et al. (2004) and Pauscal & Peters (2005) also reported an accelerated and progressive loss of lung function over time in asthmatic patients.

III. BMI and Pulmonary functions

BMI is widely used as a surrogate measure of overall adiposity because of its simplicity and high correlation with percent body fat (Norgan & Luzzi, 1982 and
Gallagher et al., 1996). In patients, body mass index has shown a trend of increase up to 30-39 years in males and 40-49 years in females. In controls, body mass index has shown a trend of increase up to 40-49 years of age in males and up to 50-59 years in females. The patients have lower values of BMI than controls with statistically significant differences in the age groups of 40-49, 60-69 and 70+ years in males and 40-49, 50-59 and 60-69 years in females (Table 16 and Fig. 14). The mean BMI among patients and control males has been found to be 21.39 kg/m² and 23.85 kg/m² respectively and in patient and control females BMI has been found to be 23.44 kg/m² and 26.61 kg/m² respectively with significant differences in the two groups (Table 52a and 52b).

Gaur et al. (2006) have also reported that BMI of asthmatic population in rural area was lower than normal population. Among the rural population, BMI of asthmatics was 18 kg/m², and normal individuals were 20 kg/m². The BMI of urban city and urban slums population with asthma and normal subjects was 22 kg/m² and 19 kg/m² respectively.

As per WHO guidelines, subjects have been classified into four categories of BMI i.e. <18.5, 18.5-24.9, 25.0-29.9 and > 30. In the present study all the pulmonary functions have shown an improvement with increase in BMI in both male and female patients, whereas in controls the pulmonary functions have shown an improvement up to 25.0-29.9 category but in the last category of >30 (obese) most of the pulmonary functions have decreased (Table 31-38 and Fig. 28-35). Pednekar et al. (2007) also reported that high BMI has a protective effect against chronic respiratory diseases but Lazarus et al. (1998) and Maiolo et al. (2003) have reported diminished lung function at both extremes
of BMI distribution. Chu et al. (2009) reported association of extreme BMI with different lung function impairment in a study of asthmatic adults in rural China. There was a U-shaped relationship between BMI and asthma in women and an association between underweight and asthma in men. Zheng et al. (2011) studied Indian and Bangladeshi population and reported positive association between low BMI and mortality primarily due to respiratory diseases and no positive association between high BMI and mortality was observed.

In India, underweight and weight loss have major public health implications, predominantly in rural areas where the leanest population has been observed. Leanness (BMI < 16 kg/m²) and lesser weight are strong determinants of overall death and chronic respiratory diseases. In the present study 31.48% male patients and 26.74% female patients have low BMI (<18.5) (Table 30). Subramanian & Smith (2006) have reported that Asian populations have a high proportion of underweight and a smaller proportion of overweight and obese persons.

IV. Waist circumference and pulmonary functions

Waist circumference is a useful parameter in clinical settings where it is particularly helpful for evaluating risk of specific diseases. Waist circumference measurements are highly reproducible and correlate with body fat mass in males and females (Wang et al., 2003).

A significant association between both overweight, increased waist circumference and asthma has been reported by Kronander et al. (2004). Waist Circumference is
correlated with both subcutaneous adipose tissue and intraabdominal adipose tissue, but it is a better predictor of intraabdominal adipose tissue—deleterious fat deposition—than BMI (Klein et al., 2007).

In the present study the subjects have been classified in two categories according to waist circumference using cut off points given by WHO Asia Pacific Guidelines (2000) i.e. > 90 cm in men and >80 cm in women were defined as abdominal obesity.

When pulmonary functions were analyzed according to waist circumference, patient males with waist circumference > 90 cm had better pulmonary functions as compared to male patients with waist circumference ≤ 90 cm, and the differences have been found to be statistically significant except for FEF 25-75% and lung age. In patient females also, pulmonary functions improved with increase in waist circumference (>80cm) (Table 40) although the differences were statistically significant only for PEFR and FEV3/FVC. In control subjects the pulmonary functions have shown improved values in subjects having waist circumference ≤ 90 cm in males and ≤ 80 cm in females but not to the level of significance (Table 41). Protective effect of high waist circumference especially for asthma patients could be due to the reason that asthma being a socially patterned disease has a higher incidence among economically weaker section of society and high BMI and waist circumference somehow reflect the better nutritional and overall health status of asthmatic patients in the population under study and this has a positive impact on pulmonary functions in asthmatic patients.
V. Waist to hip ratio and pulmonary functions

Waist to hip ratio (WHR) has been correlated with certain diseases. A WHR of 1.0 or higher is considered “at risk” for undesirable health consequences such as heart disease and other conditions associated with being overweight. As per WHO Asia Pacific prospective guidelines (2000), a WHR of 0.90 or less for men and 0.80 for women is considered safe.

In the present study, subjects represent general population of this area and have not been found to be obese as their waist hip ratio is well below 1. Waist to hip ratio profile of asthma patients and control subjects has been found to be as 0.90 in male patients and 0.91 in control subjects. In females the WHR has been found to be 0.87 in patients and 0.85 in females (Table 52a and 52b). So the present study population of males have normal waist to hip ratio according to cut off values but patient females have significantly higher values of waist to hip ratio than control females.

While analyzing pulmonary functions according to waist to hip ratio, it has been observed that in patient males, pulmonary functions except FEF25-75% improved with higher waist to hip ratio i.e.≥0.9 but the differences in the mean values have not been found to be statistically significant but patient females with waist to hip ratio less than ≤0.8 have been found to have higher values of all pulmonary functions parameters except PEFR and lung age with differences reaching level of statistical significance for FEV1/FVC and FEV3/FVC (Table 43). In controls, subjects with waist to hip ratio ≤0.9 in males and ≤0.8 in females have higher values of pulmonary functions parameters but the
differences in the mean values have not reached the level of statistical significance except for FEV1, FEV3 and lung age in males and FVC, FEV1, FEV3 and lung age in females (Table 44).

Similarly an inverse relationship between abdominal obesity and lung function has been reported in many studies (Collins et al., 1995; Carey et al., 1999; Chen et al., 2001; Harik-Khan et al., 2001; Canoy et al., 2004; Ochs-Balcom et al., 2006 and Chen et al., 2007) of middle-aged subjects.

Appleton et al. (2006) reported increased risk of asthma associated with obese levels of WC and WHR in female subjects only. Sutherland et al. (2008) also reported that abdominal obesity may mechanically affect the diaphragm and chest wall compliance leading to decreased lung volumes.

VI. Pulmonary functions according to smoking status

Stratification of asthma patients and controls according to smoking status showed that smoking in asthma patients significantly accelerated the decline in lung function as all pulmonary functions parameters i.e. FVC, FEV1, FEV1/FVC, FEF25-75%, PEFR, FEV3 and FEV3/FVC have lower values in smoker asthma patients as compared to asthma patients who did not smoke, with statistically significant differences (Table 45). Marquette et al. (1992), Ulrik & Frederiksen (1995), Lange et al. (1998), Althuis et al. (1999), Apostol et al. (2002) and James et al. (2005) have reported an accelerated decline in pulmonary functions of asthmatic smokers and an increased mortality rate as compared to asthmatic nonsmokers. Silverman et al. (2003) concluded that smokers
with asthma have to attend emergency departments with a greater frequency and moreover it has also been reported that there is poor response to antiasthma drugs in asthmatic patients who smoke and there is greater need for rescue medications (Gallefoss & Bakke., 2003 and Thomson & Spears, 2005). Asthmatic smoker patients also have reduced therapeutic response to inhaled and oral corticosteroids (Chaudhary et al., 2003; Tomlinsen et al., 2005 and Lazarus et al., 2007).

In the present study also asthmatic smokers tend to lose lung function faster, so they have more lung age (85.51 years) as compared to asthmatic nonsmokers (73.29 years). In controls, the lung age has been found to be 47.53 years and 46.10 years in smokers and nonsmokers respectively (52a and 52b). Boulet et al. (2006) reported lower ratio of FEV1/FVC in smokers, suggesting increased airway obstruction.

Cigarette smoke has the capacity to damage the bronchi in a number of ways, including direct toxicity to the bronchial epithelium, oxidative damage; recruitment of inflammatory cells, and increased epithelial permeability and smoking is associated with the development of airflow limitation in susceptible subjects (Rahman & Mcnee, 1996).

Smoking affects asthma and its response to treatment by influencing the underlying airway inflammatory process as there has been reported an increase in neutrophils in this situation (Pedersen et al., 1996 and Chalmers et al., 2001). Jha & Chaloupka (2000) and Gajalakshmi et al. (2003) have reported that smoking and tobacco use is related to chronic lung disease such as asthma and chronic obstructive lung disease in young, middle age and the elderly.
Polosa et al. (2008) have demonstrated that smoking is an important independent risk factor for new onset of asthma in allergic individuals. The genes have also been identified which are associated with increased risk of asthma in the presence of tobacco smoke exposure (Bouzigon et al., 2008).

**VII. Pulmonary functions according to duration of disease**

The duration of asthma has been found to be associated with decline in lung functions in both males and females. All the pulmonary function parameters (FVC, FEV1, FEV1/FVC, FEF25-75%, PEFR, FEV3, and FEV3/FVC) have shown a trend of decline with increase in duration of the disease up to 10 years in both males and females. In a category of more than 10 years of duration of the disease, male patients have shown an improvement in their lung functions and lung age has also decreased whereas in females a continuous decline in lung functions and increase in lung age has been observed. Moreover the rate of decline in lung function has been found to be more in the first five years following the onset of asthma (Table 47- 48 and Fig. 44-51). Postma & Lebowitz, (1995) and Holgate (2008) have also reported excessive decline in lung function prior to the time of diagnosis and also in the first years following the onset of asthma.

Like the present study Urlik et al.(1992), Cassino et al.(2000) and Kupczyk et al.,(2004) have also reported that longer duration of the disease is associated with increased decline in lung function. Rivera et al. (2007) reported a close association between the duration of disease and loss of lung function, supporting the concept of
asthma as a slow, progressive disease at least among those patients with a mild- to-moderate degree of airflow limitation.

Cibella et al. (2002) reported that in older asthmatics the rate of pulmonary function loss may slow down. Long disease duration produces a slower FEV1 decline. Age and duration of the disease are two factors which independently influence the lung function. Although in the present study there is a decline in all the pulmonary functions with ageing in both males and females but with duration of more than 10 years of disease in males functioning of pulmonary variables is better than other categories. Bellia et al. (1998) have also reported that in older asthmatics there is a lower effect of the disease duration on maximum achievable bronchodilation.

VIII. Pulmonary functions according to severity of disease

Asthma prevalence in low- to middle-income countries is at least the same or higher than in rich countries, but with increased severity. This increased level of severity may be due to various factors such as low accessibility to effective medications, multiple and uncoordinated weak infrastructures of medical services for the management of chronic diseases such as asthma especially in rural areas, poor compliance with prescribed therapy, lack of asthma education, and social and cultural factors.

In the present study pulmonary functions of asthma patients have been analysed according to severity score of asthma and it has been observed that all the pulmonary functions evaluated have decreased significantly with increase in severity in both male
and female patients (Tables 50 and 51 and Fig. 52-59). The lung age also has shown significant increase with increase in severity of disease thereby reflecting deleterious effect of severity of disease on lung function. So it is imperative to achieve good control of disease to preserve lung function.

Bai et al. (2005) have reported that patients requiring hospitalisation for acute asthma and those requiring courses of oral corticosteroids probably have the most severe worsening of airway inflammation which has been associated with an enhanced rate of lung function decline and a greater prevalence of nonreversible airflow limitation. Bai (2007) reported a significantly higher decline in mean FEV1 in patients with frequent exacerbations than asthmatics with infrequent exacerbations and may have more airway obstruction as measured by spirometric variables compared with asthma subjects not classified as severe. Fitzpatrick et al. (2006) and Moore et al. (2007) have also reported more airway obstruction in severe asthma subjects. Ten Brinke and co-workers (2001) studied 132 severe asthmatics and reported persistent airflow limitation in less than half subjects.

IX. **Sex Differences**

While studying sex differences for anthropometric and pulmonary function variables in patients and controls it has been noticed that linear measurements (stature, sitting height, subischial length) and lean body mass are significantly larger in males in both patient and control groups. Weight and waist circumference are also larger in males but the differences are not statistically significant.
The upper arm circumference and hip circumference are larger in females of both groups leading to significant differences but for hip circumference in patients the differences have not reached the level of significance. Body mass index, skinfolds and body fat are significantly larger in females in both patients and controls.

The pulmonary function variables i.e. FVC, PEFR, FEV3 and lung age are significantly larger in male patients whereas FEV1, FEV1/FVC and FEV3/FVC are larger in female patients leading to significant differences except FEV1 and FEF 25-75%. In control group all the pulmonary function variables except FEV1/FVC and lung age are significantly larger in males. FEV1/FVC is significantly more in females and the lung age is almost similar in the two groups. Osborne et al. (1998) studied a cohort of patients with physician-diagnosed asthma and reported that women had increased symptoms and decreased quality of life but demonstrated a higher mean FEV1 than men. Wijnhoven et al. (2003) also reported that among 967 asthmatic patients > 16 years old recruited from general practice in the Netherlands, women reported poorer quality of life but had higher levels of pulmonary function.

X. Correlation Coefficients

Correlation coefficients have been calculated by taking pairs of measurements as well as age. In both patients and controls, age has weak negative correlation with most of the anthropometric measurements and pulmonary functions except lung age with which the correlation is strong positive. Chatterjee and Saha (1993) have also reported an
inverse relationship between age and pulmonary functions in persons older than 30 years of age.

In patient’s males, anthropometric measurements like weight, body mass index, waist circumference, absolute body fat and lean body mass have weak to moderate positive correlation with most of the pulmonary function variables. All these anthropometric indices have weak to moderate negative correlation with lung age which means a positive impact on lung health. Whereas in control males, weak positive to weak negative correlation has been observed between anthropometric indices and pulmonary functions (Table 54 and 55).

In patient females, anthropometric indices have weak positive correlation with most of the pulmonary function variables. In control females, anthropometric indices have weak positive to weak negative correlation with most of the pulmonary function variables. Lean body mass has weak positive correlation with all the pulmonary functions except lung age in both patients and controls (Table 56 and 57).

Weak to moderate positive correlations (except lung age) have been observed in patients (males and females) indicating positive impact of BMI, waist circumference, waist to hip ratio, body fat and lean body mass on most of the pulmonary functions variables. In control (males and females) BMI, waist circumference, waist to hip ratio and body fat have been found to have weak negative correlation with most of the pulmonary functions and positive correlation with lung age. Lean body mass has weak
positive correlation with most of the pulmonary function variables in both male and female control.

Harik-Khan et al. (2001) found that BMI was inversely correlated to the FVC, FEV1 whereas Medarov et al. (2005) reported that FEV1 was not affected by BMI and it had no relationship with it. Ghabashi and Iqbal (2006) carried out a study on asthmatic patients and reported no correlation between BMI and the spirometric variables. Farida et al. (2009) have also reported that waist circumference and waist to hip ratio were not correlated to any parameter of the pulmonary functions. Chen et al. (2007) have reported negative association of waist circumference with FVC and FEV1. Amara et al. (2001); Mohamed et al. (2002) and Wannamethee et al. (2005) studied impact of lean body mass and reported positive association of lean body mass with pulmonary functions.

So in the present study asthmatic patients have been found to be lighter in weight with lesser values of circumferences and skinfolds and have lower BMI, body fat and lean body mass as compared to control subjects. The asthmatic patients have lower values of pulmonary functions and decline in the pulmonary functions is also more in patients as compared to controls. It has also been observed that smoking has significantly accelerated the decline in pulmonary functions of asthmatic patients whereas in controls although there is a decline in pulmonary functions of smokers but the differences have not reached the level of significance. Pulmonary functions have shown improvement in patients with increase in BMI and waist circumference. With increase in duration and severity of the disease in patients the pulmonary functions have exhibited more decline.
but in male patients after 10 or more years of disease duration, most of the pulmonary functions have shown improvement.

Therefore anthropometric assessment of asthma patients is of vital importance to understand the impact of disease on body morphology. As pulmonary function reflects the overall health status of the patients and is an important indicator of mortality, so it is imperative to understand the link between anthropometric profile and pulmonary functions of asthma patients to manage the disease effectively and maintain the pulmonary function status of the patients as close to normal as possible.