5. SUMMARY AND CONCLUSION

The present study was carried out to assess the association of metabolic syndrome and physical activity in an urban middle aged population. The subjects comprised of middle aged men and women visiting the OPDs of 6 Delhi hospitals for medical problems related to the components of metabolic syndrome and/or for preventive health checkups. NCEP (ATP III) criteria were used to select freshly diagnosed cases of metabolic syndrome (MS). The study consisted of collection of ground data and relevant literature for a statistical selection of probabilistic sample size of individuals with MS, aged 35 to 55 years (n = 750) calculated at the 95% confidence interval with a 5% margin of error. An equal number of non metabolic syndrome (NMS) subjects, matched for age and gender, were selected.

Suitable questionnaires were formulated to collect demographic & baseline information including age, gender, education, occupation, socio-economic status, family profile; information on lifestyle patterns like smoking and alcohol consumption; family history of the components of metabolic syndrome. Data was also collected on food consumption pattern like food habits and food preferences, meal patterns, eating out patterns etc; routine daily physical activity and exercise pattern, occupational and leisure time physical activity, physical activity during the last 3-4 years including occupation, recreation and exercise patterns.

Anthropometric measurements like height, weight and waist circumference were taken using standardized techniques and the subjects were examined for blood pressure. Data regarding biochemical parameters viz blood glucose and lipid profile was obtained from the hospital authorities.

Dietary information was gathered by diet history and 24 hour recall method record combined with a food frequency questionnaire. Phenotypic markers were assessed.
Physical activity assessment was done by a suitable structured questionnaire developed by Bharathi, Sandhya and Vas (2000) for the assessment of physical activity pattern in urban middle aged Indians. The physical activity questionnaire estimates 24 hour energy expenditure as well as components of occupational and discriminatory leisure time activity. In this questionnaire, information is collected for daily, weekly and monthly physical activity.

To validate the questionnaire for assessment of physical activity, accelerometry was used as a gold standard. Accelerometry is a physical activity monitoring technique with the basic objective of measuring the free living physical activity pattern. This was done using a calibrated water proof activity monitoring device (Actical). It was put on the wrists of 10 subjects of same age group as per the study design for three days after uploading the required information on age, height, weight. The data was then analyzed using Actical software. Information on the daily physical activity of the subjects for the same 3 days was also gathered by the questionnaire used for the study. The total energy expenditure as calculated by the two methods was then compared. The data indicated that PAL values as calculated for physical activity data collected by physical activity questionnaire and Actical method had similar results (within 10% of error). This validated the questionnaire and its applicability.

The data was statistically analyzed. Mean and standard deviations (SD) were calculated for parametric data. Odds ratio was calculated. Chi-square and t tests were used for comparison between the MS and NMS groups. The significance level used was $\alpha = 0.01$ for a two-tailed test. All statistical analyses were carried out using the SPSS 19 version statistical program.

The present study revealed the following results:

As compared to 750 subjects identified for metabolic synfrome as per NCEP ATP III criteria, a lesser number from amongst the same people could be labeled as
having metabolic syndrome on the basis of definitions given by IDF and WHO. Thus, NCEP ATP III is the better criteria to make people aware about their health problem and as an alert alarm for the population.

The 750 MS subjects comprised of 44.9% males and 55.1% females

An equal number of age and gender matched, non metabolic syndrome subjects (NMS) were recruited as controls from the same 6 hospitals from where the MS subjects had been taken.

Majority of subjects in both the groups were graduates and a fairly large number were post graduates.

Regarding occupation, 43.5% of subjects were housewives, 39.4% of subjects were in service and 17.1% were in business.

Majority of both MS and NMS subjects reported a family monthly income more than Rs 50,000 but the number was proportionately higher in the MS category.

Majority of subjects in both the groups were married (97.4%).

Regarding family type, majority of subjects (both MS and NMS) were having a joint family. The data is typical of a middle aged urban population.

The prevalence of metabolic syndrome showed an increase with age, majority being in the age group of 50-55 years (33.3% males and 29.5% females).

**Regarding diagnostic components of metabolic syndrome**, almost all MS females (89.3%) and males (85.7%) had low HDL levels – thus a major characteristic contributing to metabolic syndrome in both the genders. Elevated Blood Glucose was also prevalent in a fairly large number of both MS males and females (66.46% and 58.59% respectively). On the other hand, high BP was more prevalent in MS males (61.43%) as compared to females (54.4%). Abdominal Obesity (larger than desirable waist circumference) was a major
characteristic in a large majority of MS females (82.5%) as compared to males (51.3%). High triglyceride levels were seen more in MS males (53.7%) as compared to females (44.55%).

The prevalence of abdominal obesity in women was significantly higher than in men but the prevalence of low HDL, high blood glucose and high BP was not significantly different.

The subjects taken as controls or non metabolic syndrome (NMS) were those who had less than three components of metabolic syndrome as per NCEP ATPIII criteria. Even among the NMS subjects, a large number of both males and females had low HDL levels (53.41% and 64.64% respectively). Abdominal obesity was another component seen in a large number of NMS subjects, especially females (31.1%).

**Distribution of subjects for components of metabolic syndrome and age** showed that, in both males and females, elevated blood glucose, blood triglycerides, high blood pressure (both diastolic and systolic) and low HDL was highest in the age group of 50-55 years and the differences were statistically significant by chi-square (p<0.01). Elevated blood pressure, both systolic and diastolic, showed an increase with age. Abdominal obesity, as reflected by a larger than desirable waist circumference, was highest in females in the age group of 35-39 years and 45-49 years in case of males. The differences across the age groups, according to chi–square, were statistically significant.

A large number of MS subjects reported **family history** of diabetes, elevated blood pressure, obesity and dyslipidemia which could be a contributory factor to the occurrence of metabolic syndrome. A lesser number of NMS subjects reported a family history of these disorders although there were no significant differences as per chi-square.
Regarding physical activity profile, although a large number of subjects, both MS and NMS, reported not doing any kind of physical activity, the number of MS subjects was proportionately higher (69.5% males and 77.5% females) as compared to the NMS (55.5% males and 64.9% females). Further, the differences according to chi-square were significant. Physical inactivity could thus be a contributory factor to occurrence of metabolic syndrome.

The reason reported by majority of the subjects for physical inactivity was lack of time. Tiredness and laziness were the other reasons given for not doing physical activity.

Amongst those who reported doing some kind of physical activity, there were more of males than females in both the categories. Regarding type of physical activities done, walking was reported by majority of both MS and NMS subjects. Yoga was another activity commonly undertaken. Very few of MS subjects reported going to the gym and indulging in cardio, stretching and weight lifting exercises. On the contrary, a fairly good number of NMS subjects reported performing cardio exercises during gym hours.

The frequency and duration of exercise analyzed in terms of hours/week showed that majority of both MS and NMS subjects were performing physical activity between 2.5 hours to 5 hours/week. However, while a fairly large number of MS subjects (22.3% males and 29.1% females) were doing physical activity for less than 2.5 hours/week, a larger number of NMS subjects (41.3% males and 40.1% females) were performing physical activity for more than 5 hours a week.

Regarding recreational activities, all subjects reported viewing television and reading as their main leisure time activity and more than 50% reported listening to radio as their means of recreation. Outdoor games were reported by very few subjects and that too by NMS subjects, both males and females.
Physical activity was also analyzed on the basis of global health recommendations of physical activity given by WHO (2010). The findings revealed that as compared to the MS subjects, more of NMS subjects were doing physical activity for more than 150 minutes of moderate intensity / 75 minutes of vigorous intensity per week. A fairly large number of MS subjects (20.8% males and 30.1% females) were doing less than 150 minutes moderate/75 minutes vigorous intensity physical activity per week. The differences were statistically significant as per chi-square.

A fairly large number of both MS and NMS subjects reported not doing any physical activity in the previous years. Amongst those who reported being physically active in the past were more of NMS subjects (both males and females) as compared to the MS subjects. Further, a relatively greater number of NMS subjects (46.5% males and 61.5% females) reported doing physical activity for the last 2 years or more as compared to MS subjects (43.7% and 50.8% respectively) and the differences were statistically significant as per chi-square (p<0.01).

A fairly large number of MS subjects, both males and females (50.9% and 55.7% respectively), reported decrease in physical activity levels over the previous years as compared to NMS subjects (25.2% and 35.5% respectively). The differences were statistically significant in both males (p<0.01) and females (p<0.05) as per chi-square.

In quantitative terms, physical activity was analyzed on the basis of PAL levels as given by FAO (2004). The findings reflected that a fairly large number of MS males were having PAL values suggestive of a sedentary lifestyle as compared to NMS males (65.57% vs 32.35%). Further, more of MS female subjects were sedentary as compared to NMS females (70.9% vs 45.27%) and in both MS and NMS groups, more of females were sedentary as compared to males. There was a significant difference (p<0.01) in PAL levels of MS and NMS
subjects as per chi-square. Odds ratio further showed a 3 times greater risk of MS with decrease in physical activity in terms of PAL values.

**Physical activity analyzed on the basis of MET/week**, revealed that a fairly large number of MS subjects (69.4% males and 77.5% females) were ‘inactive’ as they were not performing any kind of aerobic physical activity. The relative number of NMS subjects in this category was lesser and the differences were statistically significant as per chi-square (p<0.01). Further, more of NMS subjects (27.8% males and 17.7% females) were ‘highly active’ i.e doing physical activity more than 1000 MET minutes/week as compared to MS subjects (12.3% and 10.9% respectively). The differences were statistically significant as per chi-square (p<0.01). Thus, lack of adequate aerobic physical activity for majority of MS subjects, both males and females, could be the reason for abdominal obesity and other components of metabolic syndrome.

**Physical activity of the subjects in terms of PAL values was correlated with individual diagnostic components of metabolic syndrome.** The results showed that relatively more of sedentary subjects (64%) were having higher fasting blood glucose as compared to moderately active subjects (58.1%) although the difference was not statistically significant by chi-square. The odds ratio indicated that physical inactivity increased the risk of elevated blood glucose levels and hence diabetes by 0.783 times.

More of subjects who were sedentary (49.8%) were having elevated triglycerides as compared to moderately active subjects (46.1%) although the difference was not statistically significant. The odds ratio indicated that physical inactivity increases the risk of elevated triglycerides by 0.872 times.

Regarding abdominal obesity, 60.4% of MS females who were sedentary (as per PAL values) were having higher than desirable waist circumference as compared to 51.3% of moderately active females. Similarly, more of MS males
(50.7%), who were sedentary, were having higher than desirable waist circumference as compared to moderately active males (42.6%). Odds ratio indicated that physical inactivity increases the risk of abdominal obesity by 1.80 times in females and 1.17 times in males.

More of metabolic syndrome subjects, both females (93.5%) and males (90.4%), who had sedentary lifestyle (as per PAL values) were having low HDL cholesterol as compared to moderately active subjects (71.6% and 67.2% respectively). The differences were statistically significant as per chi-square ($p<0.05$). This states that physical activity plays an important role in improving and increasing the HDL cholesterol. The odds ratio indicated that physical inactivity increases the risk of low HDL cholesterol by 1.12 times in females and 1.43 times in males.

More of metabolic syndrome subjects, who were sedentary (as per PAL values) were having high blood pressure, both systolic (53.3%) and diastolic (60.7%), as compared to moderately active subjects (34.3% and 42.3% respectively). The differences were statistically significant as per chi-square ($p<0.01$). This stated that physical activity plays an important role in decreasing the blood pressure. The odds ratio indicated that physical inactivity increases the risk of systolic blood pressure by 1.80 times and diastolic blood pressure by 1.85 times.

Regarding metabolic syndrome and BMI classification, 81% of the MS subjects were in the category of obese class I and class II as compared to 35.2% of the NMS subjects. The differences were statistically significant as per chi-square ($p<0.01$). Thus, obesity was predominant in MS subjects. However, a large number of NMS subjects were also obese which would make them susceptible to metabolic syndrome if proper lifestyle and dietary interventions are not taken care. Differences between MS and NMS subjects, in all the categories of BMI, were statistically significant as per chi-square ($p<0.001$).
Association of physical activity with BMI, stated that more of MS subjects (84.7%), who were sedentary as per PAL values, were obese as compared to moderately active subject (73.3%), although this difference was not statistically significant. The results are reflective of physical inactivity as a contributory factor to obesity.

According to NCEP (ATP III) criteria, those having any 3 components or more are considered to be subjects of metabolic syndrome. Regarding the number of diagnostic components of metabolic syndrome present, results showed that a substantial number of MS subjects had more than 3 components. Amongst the NMS subjects, a substantial 20.8% were having 2 components and were thus at a risk of having metabolic syndrome with the addition of one more component. The differences were statistically significant as per chi-square (p<0.01).

When physical activity of the subjects in terms of PAL was associated with the number of diagnostic components of metabolic syndrome, the data revealed that even among the MS subjects, the number of components were more in case of sedentary subjects as compared to moderately active subjects. The difference was statistically significant as per chi-square (p<0.05).

The mean values of various components of metabolic syndrome were also analyzed in relation to the number of MS diagnostic components. Data showed that the mean values of waist circumference, blood glucose, blood triglycerides and blood pressure (both systolic and diastolic) increased with increase in the number of metabolic syndrome diagnostic components. In a similar trend, HDL levels decreased with increase in the number of metabolic syndrome diagnostic components. The differences were statistically significant by one way analysis of variance (p<0.01). The data is thus indicative that the severity of any one component was compounded by the presence of other problems.
Dietary patterns revealed that 60-70% of subjects reported having 4-5 meals/day viz breakfast, mid day, lunch, evening tea and dinner which are typical of an urban lifestyle.

Regarding food habits, 65% of subjects in both groups were lacto-vegetarian and 20-25% were non-vegetarian. Consumption of fish, chicken and mutton was reported by a larger number of MS subjects as compared to NMS subjects. Almost 50% of the subjects were eating in between the meals. Types of food consumed in between the meals were mainly fried food, tea and coffee. Consumption of fruits between meals was reported by a lesser number in both the groups.

The data on skipping meals revealed that a fairly large number of subjects of both the groups reported skipping meals, mainly breakfast and lunch. However, more of MS subjects (45.1%) skipped breakfast as compared to NMS subjects (21.9%). The difference was statistically significant as per chi-square (p<0.01). Some of the reasons given for skipping meals were lack of appetite, weight loss and lack of time due to work schedule.

Regarding food preferences, the present study revealed that more of MS subjects reported preference for deep fried (86.7%) and shallow fried foods (89.9%) as compared to NMS subjects (75.6% and 82% respectively). According to chi-square, this difference was statistically significant in regard of both shallow fried and deep fried foods (p<0.01). This could be the reason for high triglycerides level and high abdominal waist circumference in MS subjects.

The data was gathered on frequency of consumption of a variety of processed foods. These were categorised as high sodium foods, high sugar foods, and high fat foods. A fairly high frequency of consumption (5-6 times a week or more) of these foods was reported by a large number of subjects in both the groups. This indicates that both MS and NMS subjects were consuming high
amount of sodium, fat and sugar based products; this could be a reason for the prevalence of high blood pressure, triglycerides and high fasting blood glucose in many of the subjects.

The subjects were categorized on the basis of consumption of fruits and vegetables. Results revealed that only about 50% of the subjects in both groups reported consumption of 4 servings or more of fruits and vegetables in a day.

Regarding type of fat, consumption of vegetable oils rich in PUFA was reported by more of MS subjects (91.2%) as compared to NMS subjects (81.07%), whereas more of NMS subjects reported consumption of vegetable oil rich in MUFA as compared to MS subjects. The differences were statistically significant (p<0.01) as per chi-square. Desi ghee was reportedly consumed by a large number of MS subjects (92.4%) as well as NMS subjects (88.26%), and the difference was not statistically significant. Only 13% of MS subjects reported frequent change of oil used as compared to NMS subjects (30%) and the difference was significant (p<0.01) according to chi square.

Regarding consumption of type of milk and other beverages, majority of both metabolic syndrome and non metabolic syndrome subjects were consuming full cream milk and the differences were not significant. A large majority of subjects in both the groups also reported consumption of sweetened beverages. However, more of MS subjects (91.2%) reported addition of sugar in the milk as compared to NMS subjects (76.54%) and this difference was statistically significant as per chi-square (p<0.01).

The findings thus denote that metabolic syndrome subjects were consuming more sugar based beverages as compared to non metabolic syndrome subjects which could be a contributory reason for high blood glucose levels as well as high abdominal waist circumference among metabolic syndrome subjects.
Regarding smoking and alcohol, majority of subjects of both groups reported no smoking and alcohol consumption. There was no significant difference between metabolic and non metabolic syndrome subjects regarding smoking and alcohol consumption. Amongst those who reported smoking, more of MS subjects were smoking 3-4 cigarettes a day whereas more of NMS subjects reported smoking 1-2 cigarettes a day. Similarly, more of MS subjects reported consuming 3-4 pegs of alcoholic beverages at a time as compared to more of NMS subjects taking 1-2 pegs. Whisky was the most common alcoholic drink reported by the subjects.

Regarding dietary quantitative analysis, the mean intakes of energy and essential nutrients in relation to the respective RDAs for MS and NMS subjects were analysed.

The mean intake of energy in MS males was 1954 Kcals+398 and that of NMS males was 1787 Kcals+452. The energy intake in relation to RDA was thus 84.2% for MS, being higher than that of NMS males, which was 77%. The difference was statistically significant as per t-test (p<0.01).

The mean intake of protein was 66.81g+19.05 and 59.89g+16.96 for MS and NMS males respectively. With respect to the RDAs, the percent adequacy of protein intake for MS males was 121.4% as compared to 99.8% for NMS males. MS males thus had a higher intake of protein as compared to NMS males and the difference was statistically significant as per t-test (p<0.01).

The mean intake of fat in MS males was also higher (55.76g+17.13) as compared to that of NMS males (52.33g+23.62).

The amount of fat consumed was also analyzed in terms of energy intake. In both MS and NMS males, the percent energy intake from fat was less than 30% (25.7% and 24.8% respectively).
Although the mean intakes of **iron, calcium, thiamine, niacin and vitamin C** was more than the RDAs for both MS and NMS males, the percentage adequacy was higher in MS males as compared to NMS males. The consumption of **riboflavin** in relation to RDA was higher in MS males (118.3% percent adequacy) as compared to NMS males (87.5%). Differences were statistically significant for thiamine, niacin and calcium (p<0.01) but not for riboflavin (p=0.115), iron (p=0.942) and vitamin C consumption (p=0.889).

Although the mean intake of **Vitamin A** was higher for NMS males as compared to MS males, the percent adequacy of vitamin A intake was low for both the groups and the difference was not statistically significant (p=0.992).

**Regarding females**, the mean intake of **energy** in MS females was 1764 kcal+423 and that of NMS females was 1590 kcal+328. In relation to RDAs, the percent of energy intake for MS females was higher (92.8%) than that of NMS females (68.59%) and the difference was statistically significant as per t-test (p<0.01).

In case of **proteins** also, the mean intake of MS females was 59.29g+25.15 and that of NMS females was 53.72g+13.30, the percent adequacy for MS females being 107.8% and for NMS females 89.5%. The difference was statistically significant as per t-test (p<0.01).

The mean intake of **fat** was higher in MS female (56.67g+15.89) as compared to NMS females (46.04g+14.3).

In terms of percent of energy intake from fat, although among both MS and NMS females, it was less than 30%, it was higher in MS females then NMS females (26.8% and 21.8% respectively).

Although the mean intakes of **calcium, thiamine and niacin** were more than the RDAs for both MS and NMS females, the percentage adequacy was higher in
MS females as compared to NMS females. The consumption of riboflavin in relation to RDA was higher in MS females (113.5% percent adequacy) as compared to NMS females (79.6%). Differences were statistically significant for thiamine, niacin (p<0.01) but not for riboflavin (p=0.886) and calcium intake (p=0.964). Both MS and NMS females had a high percentage adequacy of iron intake.

The mean intake of Vitamin C was higher in NMS females as compared to MS females but the difference was not statistically significant (p=0.526).

Although the mean intake of Vitamin A was higher for MS females as compared to NMS females, the percent adequacy of vitamin A intake was low for both the groups and the difference was not statistically significant (p=0.064).

Karl Pearson’s correlation was done for diagnostic components of metabolic syndrome, BMI and physical activity. The data revealed that each MS diagnostic component had a positive significant correlation with other components except HDL where the correlation was negative. BMI had a strong positive, significant association with all components except HDL, the correlation being negative. PAL showed a negative correlation with all components except HDL, where the correlation was positive, but the significant correlation was only with BP (both systolic and diastolic).

Logistic regression analysis done on independent nutritional factors that contribute to metabolic syndrome revealed that energy, fats, carbohydrates and thiamine showed a strong positive, significant association with metabolic syndrome. On the other hand, protein, fiber, iron, niacin and folic acid were found to be negatively and significantly associated. No significant association was found in case of calcium, riboflavin, vitamin A and vitamin C.

Another logistic regression analysis done for independent factors that contribute to metabolic syndrome stated a positive significant association of
smoking and drinking alcohol with metabolic syndrome, and a negative significant association of PAL levels with metabolic syndrome.

**Phenotypic markers** analyzed in both MS and NMS subjects revealed that 50% of MS subjects had phenotypic markers of metabolic syndrome in the form of buffalo hump and double chin. The present study thus revealed that physical inactivity may contribute to metabolic syndrome through its effect on vital anthropometric, clinical and biochemical parameters.