Pakistan J. Zool., vol. 51(5), pp 1761-1768, 2019. DOI: http://dx.doi.org/10.17582/journal.pjz/2019.51.5.1761.1768

# Association of Lifestyle and Physical Activity with the Components of Metabolic Syndrome - A Study of Bank Employees in Lahore, Pakistan

**Rabia Khalid[1], Saleema Bashir Shams[1], Bibi Nazia Murtaza[1,*], Gaitee Joshua[1], Saira Mushtaq[1], Hassan Al-Talhi[2] and Abdulaziz Al-Amri[2]**

*[1]Department of Zoology, Kinnaird College for Women, 93-Jail Road, Lahore 54000, Pakistan*

*[2]Department of Biochemistry, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia*

**Article Information**
**Received 11 November 2018**
**Revised 05 January 2019**
**Accepted 16 January 2019**
**Available online 24 June 2019**

**Authors' Contribution**
**SBS and GJ conceived the idea and supervised the project. RK, SM, HA, AA and BNM conducted the research, RK and BNM wrote the manuscript.**

**Key words**
**Physical activity, BMI, Obesity, Blood glucose, Lipid profile.**

## ABSTRACT

Metabolic syndrome (MetS) leads to millions of preventable cases and deaths worldwide. Present study reveals the components of metabolic syndrome among the bank employees in Lahore area of Pakistan. Total 530 male individuals were recruited in the study. Associations of physical activity and sedentary behaviors with the tendencies of metabolic syndrome were evaluated. The experimental and laboratory values for BMI, total cholesterol (TC), total triglycerides (TG), high density lipoproteins (HDL), low density lipoproteins (LDL) and fasting blood glucose (FBG) were used to demonstrate the incidence of metabolic syndrome. Overall, 39.025% of bank employees and 22.53% of randomly selected control individuals have metabolic syndrome. Among the bank employees, prevalence of obesity was 67.53% and in general population it was 57.1%. The mean values of body mass index (BMI) for bank employees and control population was 24.10± 0.5 kg/m$^2$ and 20.43±1.0 kg/m$^2$, respectively. Analysis of the components of metabolic syndrome demonstrate an abnormal level of low density lipoproteins (LDL) 24.4% and 17.5%, total cholesterol 15% and 7.8%, triglycerides 17.35% and 8.8%, fasting blood glucose 24.49% and 16.5% among bank employees and general population, respectively. Our studies have revealed that the high intake and less caloric burning due to inactive lifestyle has placed the bank employees at higher risk for MetS leading to CVD, diabetes type-II, atherosclerosis and hypertension.

## INTRODUCTION

Metabolic syndrome (MetS) is a cluster of cardiovascular risk factors including hypertension, low blood concentration of high-density lipoproteins (HDL), elevated cholesterol, increased low density lipoproteins (LDL), elevated fasting triglycerides (TG), abdominal obesity and higher fasting blood glucose (FBG) (Zimmet *et al*., 2007; Anagnostis, 2012; Huffman *et al*., 2014; Suarez-Ortegón and Aguilar-de Plata, 2016). Body mass index (BMI) is the most common parameter used for the measurement of visceral abdominal obesity (Jia *et al*., 2003). The connection between obesity, MetS and type 2 diabetes mellitus (DMT2) and other diseases has been demonstrated in the recent years (Zhang *et al*., 2015; Vukovic *et al*., 2015). In case of MetS, the risk of DMT2 increases by 5 times and chances of cardiovascular disease (CVD) are doubled (Isomaa *et al*., 2001; McNeill *et al*., 2005; Alberti *et al*., 2005). Obesity and MetS are the leading cause of preventable death and avoidable health care burden worldwide. According to the estimates physical idleness causes almost 10-16% of diabetes, 22% of ischemic heart disease resulting in 2 million annual deaths worldwide (Laaksonen *et al*., 2002; Warren *et al*., 2010; Hamasaki, 2016). Physical activity and diet pattern have a significant negative correlation with the incidence of MS in adults and children (Brage *et al*., 2004; He *et al*., 2014). A moderate exercise can decrease the risk of MetS in men, can reduce the chances of hypertension (Ladabaum *et al*., 2014). A positive association has been reported between sedentary behavior and risk of MetS, abnormal BMI and waist circumference (Xiao *et al*., 2016). An association has also been demonstrated between lifestyle, long sleep durations and MetS (Durnin and Womersley, 1974). Present study was conducted to evaluate different lifestyle associated parameters of bank employees and healthy control population in Lahore Pakistan. The incidence of MetS and obesity was determined by the estimation of

* Corresponding author: nazi.murtaza@kinnaird.edu.pk
0030-9923/2019/0005-1761 $ 9.00/0

plasma lipid profile and fasting blood glucose (FBG) of the bank employees and control population.

## MATERIALS AND METHODS

*Study design*

It was a cross-sectional analytical study of bank employees.

*Inclusion criteria*

Healthy bank employees in the Lahore region were recruited in the study. The individuals suffering from diabetes, CVD, hypertension, renal failure and hepatitis were excluded. The control population included randomly selected individuals who were students, laborers, school teachers, shopkeepers *etc*.

*Ethical approval*

Participants were requested to read the information comprising the aims and objectives of study and to ask any question before providing written informed consent to participate. After willingness to participate in the study, each participant was assigned a reference number which was used in all future analysis to keep the data anonymous and confidential. Permission for publication of data was also obtained from participants. Ethical approval for the study was obtained from the Research Ethics Committee of Kinnaird College for Women. Each volunteer participant was provided with a self-reporting questionnaire about the demographic data, daily activities, tendency to use of oil rich food, use of transport types, participation in sports, exercise, awareness about reasons and consequences of obesity *etc*. The questionnaire was completed in the presence of a member of research team to avoid any confusion.

*BMI and lifestyle analysis*

Weight and height of participants was measured using a stadiometer, and weighing machine, without shoes and up to maximum accuracy. The criteria of World Health Organization (WHO) for the BMI (weight / height$^2$; (kg/m$^2$) calculations was used. The exact circumference of waist and hip was measured with accuracy using the measuring tape and waist to hip ratio was calculated, dividing waist the circumference by hip circumference. Measuring the skin thickness at biceps, triceps and subscapular areas, total body fat was determined by the procedure described in the literature.

*Blood lipid and glucose analysis*

An expert nurse was hired to collect 10 mL blood sample from each participant after 12 h fasting, transferred to a serum separator tube with clot activator. Serum was isolated by centrifugation at 2,500 rpm for 15 min and stored at −80°C in labelled tubes. These samples were used for the estimation of the total cholesterol, LDL-cholesterol, HDL-cholesterol (HDL-C), TG and FBG levels. The reference values used in the present study were adopted from the information available in the literature (USFDA, 2014; Koumaré *et al*., 2015; Kidd *et al*., 2016). The MetS was defined according to the guidelines given in literature. For obesity the waist circumference ≥94 cm for European men and ≥80 cm for European women, with ethnicity specific values for other groups, specifically 90 cm for South Asian and Oriental origin men. Participants having obesity and any two out of the following four factors was confirmed for MetS: (i) raised TG level: ≥150 mg/dL (1.7 mmol/L), or specific treatment for this lipid abnormality; (ii) reduced HDL -C: <40 mg/dL (1.03 mmol/L) in males and <50 mg/dL (1.29 mmol/L) in females, or specific treatment for this lipid abnormality; (iii) raised blood pressure: systolic BP ≥ 130 or diastolic BP ≥ 85 mmHg, or treatment of previously diagnosed hypertension; (iv) raised FPG ≥100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes if >5.6 mmol/L or 100 mg/dL.

*Statistical analysis*

Data about all variables was collected and analyzed. SPSS (version 20.0) was applied for statistical analysis. Bivariate correlation was applied with the significance level taken to be $p < 0.05$.

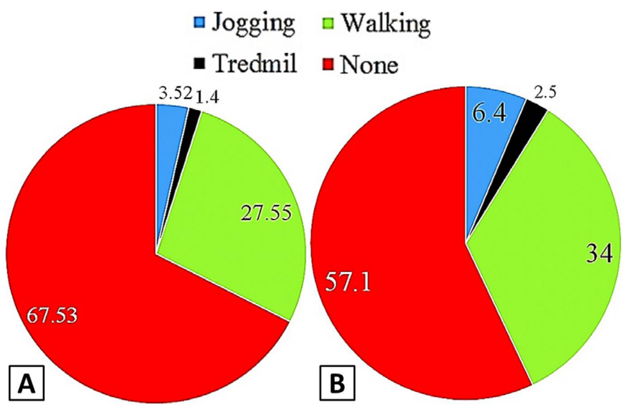


Fig. 1. Comparative analysis of physical activity: A, bank employees; B, general (control) population.

## RESULTS

The fasting blood samples were obtained from 330 individuals (230 bank employees and 100 control) with the mean age of 34.6 years. A vast majority of (67.53%) of them had no exercise like walking/ treadmill exercise, jogging in the field *etc*. The proportion of individuals with no exercise was comparatively low (57.1%) (Fig. 1). The bank employees had more tendency to use oil rich food during the breakfast and dinner as compared to the general population (Fig. 2). Only 3.06% of bank employees were using public transport, all others were using bike or car. On the other hand 25% of control population (who were laborers, students and teachers) were using public transport. None of the bank employees were using cycle as a way of transportation while 6.5% of control population was using cycles (Fig. 3). Analysis of lipid profile and FBG level was carried out. Through questionnaire the food habits, ways of transport and exercise pattern were also determined.

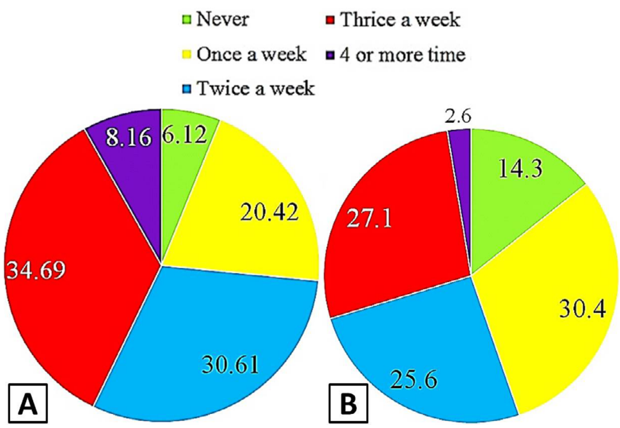


Fig. 2. Intake of oil rich food in breakfast: A, bank employees; B, general (control) population.

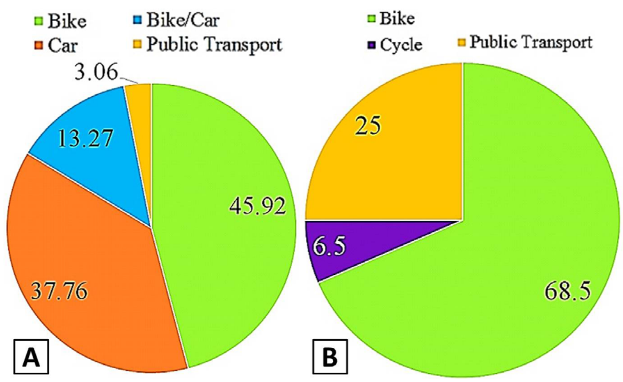


Fig. 3. Use of transportation facilities. A comparative analysis of bank employees (A) and general (control) population (B).

About 45% of investigated bank employees and 57% of control subjects had normal BMI and central body circumference. The percentage of obesity was 16.33% and 14%, respectively among the bank employees and control population. Similarly the percentage of overweight and underweight individuals was also determined (Fig. 4). Plasma analysis revealed that 24.49% of bank employees and 16.5% of control population was diabetic. The percentage prediabetic individuals were significantly high among the employees. Concentration of LDL of 24.4% of employees and 17.5% of control subjects was higher than upper reference range. Similarly, the 15% of bank employees had abnormal total cholesterol, 17.35% and 22.6% had abnormal TG and HDL, respectively (Fig. 5). Mean values of BMI were 24.10± 0.5 kg/m$^2$ and 20.43±1.0 kg/m$^2$ for bank employees and control population, respectively were significantly different with (p = 0.05). There was no significant difference between the mean weight and age of participants of both groups. The corresponding mean values for TG (191.32 ±1.2; 120.51±1.1), total cholesterol (196.08±0.7; 165.98± 0.9) and FBG (121.16 ± 1.1; 96.0±1.0) for bank employees and control population were different significantly (p = 0.001) (Table I). The prevalence of MetS was 39.025% and 22.53% among the bank employees control subjects, respectively.

**Table I.- Correlation between the lipid profile, FBG (Fasting Blood Glucose) and BMI (Body Mass Index) of total participants, bank employees and general population (control). Values are expressed as Mean±SD.**

| Variables | Total participants (n = 530) | Bank employees (n = 430) | General population (control: n = 100) | p-value |
|---|---|---|---|---|
| BMI (Kg/m$^2$) | 22.26±1.3 | 24.10±0.5 | 20.43±1.0 | 0.050* |
| Weight (Kg) | 75.90±1.1 | 81.14±2.4 | 70.57±2.1 | 0.250 - |
| Age (Years) | 34.10±2.1 | 35.21±2.5 | 33.0±2.7 | 0.400 - |
| TC (mg/dl) | 181.03±1.1 | 196.08±0.7 | 165.98±0.9 | 0.001** |
| TG (mg/dl) | 155.90±1.4 | 191.32±1.2 | 120.51±1.1 | 0.001** |
| LDL (mg/dl) | 112.69±2.3 | 124.69±1.5 | 100.7±1.6 | 0.050* |
| HDL (mg/dl) | 37.17±2.6 | 33.84±2.0 | 40.5±2.3 | 0.250 - |
| FBG (mg/dl) | 108.58±2.7 | 121.16±1.1 | 96.0±1.0 | 0.001** |

TC: <200, normal; 200-239, borderline high; >240, high; LDL: <100, normal; 100-129, above optimal; 130-159, borderline high; 160-189, high; >190, very high; TG: < 150, normal; 150-199, borderline high; 200-499, high; ≥ 500, very high; FBG: 70-100, normal; 101-125, pre-diabetic; ≥ 125, diabetic; BMI: < 18.50, underweight; 18.50 - 24.99, healthy weight; 25.00 - 29.99, over weight; ≥ 30, obese; HDL: ≥ 60, normal; 40 – 59, the higher, the better; < 40, abnormal/risky. *, significant values; **, highly significant values; -, non-significant values.

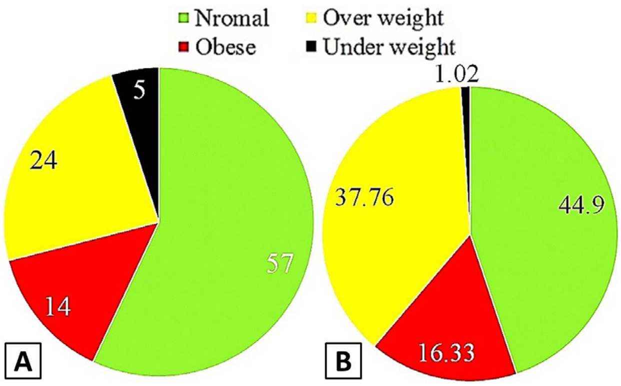


Fig. 4. The prevalence of obesity among the studied populations: A, bank employees; B, general (control) population.

## DISCUSSION

Banking is considered as a luxurious profession in developing countries like Pakistan. In the present study, we have found that the prevalence of MetS and obesity is considerably higher among the bank employees as compared to the general population in the Lahore area of Pakistan. We have also found that the moderate to vigorous physical activity are preventing factors for the components of MetS. Food habits are also found to play an important role in the regulation of MetS components. In the present study we have found that 67.53% of investigated bank employees have no routine exercise, the percentage of such individuals was 57.1 in the general population, 27.55% of bank employees and 34% of control population had regular walk. The percentage of individuals having strenuous exercise were 4.9% and 8.9% among the bank employees and control population, respectively (Fig. 1). Overall, 73.46% of bank employees and 55.3% of control population was using oil rich foods regularly (Fig. 2). A vast majority (96.95%) of bank employees were using bike or car for their transportation. In case of general population 68% were using bike, 25% were using public transport and 6.5% were using cycle as a mean of transportation (Fig. 3). The above findings have revealed that the bank employees have more sedentary lifestyle, less physical activity and use comparatively high lipid diet as compared to the control population. We have found that 44.9% of bank employees and 57% of general population had normal body weight, 37.76% of bank employees and 24% individuals of control population were overweight. The percentage of underweight individuals among general population was five times less than the bank employees (Fig. 4). The great proportion of overweight and obese individuals among the bank employees seems to be the consequence of low physical activity and oil rich diet (Huffman *et al*., 2014). Recent studies have revealed that moderate to vigorous physical activity can decrease the risk of MetS from 30% to 47% (Esteghamati *et al*., 2009).

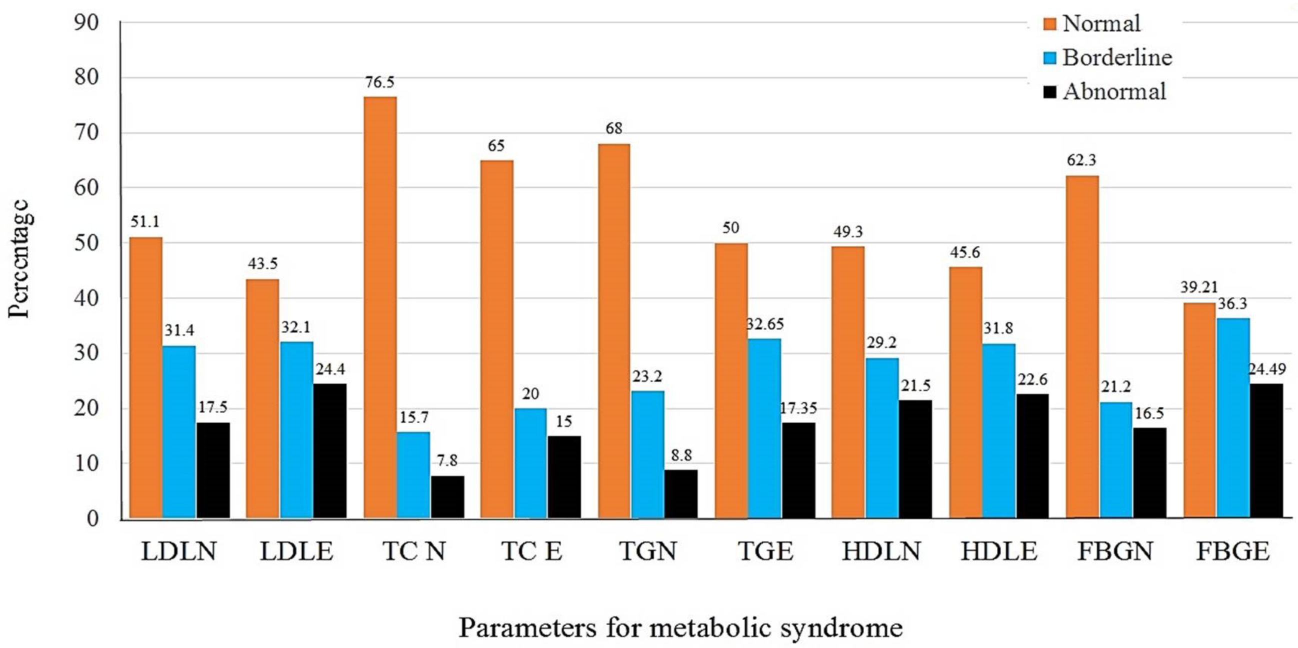


Fig. 5. The percentage of general population (N) and bank employees (E) with normal, border level and abnormal glucose level, BMI and lipid profiles.

A possible explanation for this association of physical activity with reduced MetS, obesity and resulting diabetes is induction of mitochondrial biogenesis in skeletal muscles by heavy exercise, which comprises about 80 to 90% of all insulin sensitive tissues. Recently, it has found to play important role in preventing diabetes type 2 (Zurlo *et al*., 1990; Hesselink *et al*., 2016). The increased number and functional capacity of mitochondria is vital to increase the rate of oxidative phosphorylation and helps to utilize fatty acids (Holloszy and Coyle, 1984), the excess of fatty acids can cause metabolic dysfunction of skeletal muscles (Tumova *et al*., 2016). Contrary to the above, production of reactive oxygen species (ROS) is increased by mitochondrial dysfunction. Hence, the impaired mitochondrial biogenesis plays an important role in insulin resistance and obesity (Szendroedi *et al*., 2012; Yuzefovych *et al*., 2013). We have also investigated the plasma components of metabolic syndrome. The prevalence of diabetes was found 24.49% and 16.5% in bank employees and control population. A considerably high percentage (36.3%) of employees were pre-diabetic indicating a clear link of low physical activity and diet pattern with the onset of diabetes (Fig. 5). Recent reports have also shown such associations (Smith *et al*., 2016). According to our results, the plasma levels of LDL, TC and TG are significantly higher in bank employees as compared to the control population (Fig. 5; Table I). Elevated LDL and cholesterol have been considered as main preventable plasma component to reflect the mechanisms of MetS development in parallel with insulin resistance (Hurtado-Roca *et al*., 2017). Similarly, TG contribute to MetS by an increase in the waist circumference and MBI (Tao *et al*., 2016; Dharuni *et al*., 2016). We found that the mean BMI of bank employees were considerably high as compared to that of general population (control) (Table I). As a component of MetS, BMI has an important role in the CVDs. It has been reported that BMI value 25 kg/m$^2$ or above increases the chances of coronary artery disease (CAD) (Hulten *et al*., 2017). MetS has not a single cause, it is a cluster of metabolic abnormalities. Several hereditary and environmental factors contribute to MetS including inevitable genetic factors such as hypertension, type II diabetes, family history and ethnic background (Rampal *et al*., 2012; Das *et al*., 2012). The preventable risk factors include low physical activity and dietary habits (Wagner *et al*., 2012). According to our results the prevalence of MetS is 39.025% and 22.53% among the bank employees control subjects, respectively. According to the reports, the incidence of MetS is rapidly increasing in the world (Chan *et al*., 2009). In the developing countries the prevalence ranges from 9.8% to 46.5% (Misra and Khurana, 2008). It is 15.1% in Chinese (Gul and Hafizullah, 2010), 20.8% in Japanese (Hao *et al*., 2007) and 13.7% in US Americans (Palaniappan *et al*., 2003). Our study indicates that the prevalence of general population is comparable with Japanese population. However, the bank employees have significantly high prevalence of MetS. Sedentary lifestyle, mental exertion and low physical activity seem to have an associated with high prevalence of MetS among the bank employees in Lahore, Pakistan.

## CONCLUSION

In our observation, the bank employees have significantly high prevalence of MetS. Sedentary lifestyle, mental exertion and low physical activity seem to have an associated with high prevalence of MetS among the bank employees in Lahore, Pakistan. The investigated community is under the threat of CVDs and DMT2, atherosclerosis and hypertension. It was concluded that the physical activity can effectively prevent and control the components of MetS.

## ACKNOWLEDGEMENTS

The authors are grateful to the volunteers who participated in the study.

*Statement of conflict of interest*

The authors declare no conflict of interest.

## REFERENCES

Alberti, K.G.M.M., Zimmet, P. and Shaw, J., 2006. Metabolic syndrome - a new world-wide definition. *Lancet*, **366**: 1059-1062. https://doi.org/10.1016/S0140-6736(05)67402-8

Anagnostis, P., 2012. Metabolic syndrome in the Mediterranean region: Current status. *Indian J. Endocrinol. Metabol*., **16**: 72-80. https://doi.org/10.4103/2230-8210.91195

Brage, S., Wedderkopp, N., Ekelund, U., Franks, P.W., Wareham, N.J., Andersen, L.B. and Froberg, K., 2004. Features of the metabolic syndrome are associated with objectively measured physical activity and fitness in Danish children: The European youth heart study (EYHS). *Diabet. Care*, **27**: 2141-2148. https://doi.org/10.2337/diacare.27.9.2141

Chan, J.C., Malik, V., Jia, W., Kadowaki, T., Yajnik, C.S., Yoon, K.H. and Hu, F.B., 2009. Diabetes in Asia: Epidemiology, risk factors, and pathophysiology. *J. Am. med. Assoc.,* **301**: 2129-2140. https://doi.org/10.1001/jama.2009.726

Das, M., Pal, S. and Ghosh, A., 2012. Family history of type 2 diabetes and prevalence of metabolic syndrome in adult Asian Indians. *J. Cardiovasc. Dis. Res.*, **3**: 104-108. https://doi.org/10.4103/0975-3583.95362

Dharuni, R., Maruthi-Prasad, B.V., Vishwanath, H.L. and Harish, R., 2016. Evaluation of triglyceride: HDL-C ratio and Non-HDL-C as harbingers of increased cardiovascular risk in metabolic syndrome. *Int. J. Res. med. Sci.*, **4**: 4050-4054.

Durnin, J.V. and Womersley, J.V.G.A., 1974. Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 years. *Br. J. Nutr.*, **32**: 77-97. https://doi.org/10.1079/BJN19740060

Esteghamati, A., Khalilzadeh, O., Rashidi, A., Meysamie, A., Haghazali, M., Abbasi, M., Asgari, F. and Gouya, M.M., 2009. Association between physical activity and metabolic syndrome in Iranian adults: National surveillance of risk factors of non-communicable diseases (SuRFNCD-2007). *Metabolism*, **58**: 1347-1355. https://doi.org/10.1016/j.metabol.2009.04.019

Gul, A.M. and Hafizullah, M., 2010. Does BMI affect cholesterol, sugar, and blood pressure in general population? *J. Ayub med. Coll. Abbottabad*, **22**: 74-77.

Hamasaki, H., 2016. Daily physical activity and type 2 diabetes: A review. *World J Diabet.,* **7**: 243-251. https://doi.org/10.4239/wjd.v7.i12.243

Hao, Z., Konta, T., Takasaki, S., Abiko, H., Ishikawa, M. and Takahashi, T., 2007. The association between microalbuminuria and metabolic syndrome in the general population in Japan: The Takahata study. *Intern. Med.*, **46**: 341-346. https://doi.org/10.2169/internalmedicine.46.6056

He, D., Xi, B., Xue, J., Huai, P., Zhang, M. and Li, J., 2014. Association between leisure time physical activity and metabolic syndrome: A meta-analysis of prospective cohort studies. *Endocrine*, **6**: 231-240. https://doi.org/10.1007/s12020-013-0110-0

Hesselink, M.K., Schrauwen-Hinderling, V. and Schrauwen, P., 2016. Skeletal muscle mitochondria as a target to prevent or treat type 2 diabetes mellitus. *Nat. Rev. Endocrinol.*, **12**: 633-645. https://doi.org/10.1038/nrendo.2016.104

Holloszy, J.O. and Coyle, E.F., 1984. Adaptations of skeletal muscle to endurance exercise and their metabolic consequences. *J. appl. Physiol. Respir. Environ. Exerc. Physiol.*, **56**: 831.

Huffman, K.M., Sun, J.L., Thomas, L., Bales, C.W., Califf, R.M., Yates, T., Davies, M.J., Holman, R.R., McMurray, J.J., Bethel, M.A. and Tuomilehto, J., 2014. Impact of baseline physical activity and diet behavior on metabolic syndrome in a pharmaceutical trial: Results from navigator. *Metabolism*, **63**: 554-561. https://doi.org/10.1016/j.metabol.2014.01.002

Hulten, E.A., Bittencourt, M.S., Preston, R., Singh, A., Romagnolli, C., Ghoshhajra, B., Shah, R., Abbasi, S., Abbara, S., Nasir, K. and Blaha, M., 2017. Obesity, metabolic syndrome and cardiovascular prognosis: From the partners coronary computed tomography angiography registry. *Cardiovasc. Diabetol.*, **16**: 14. https://doi.org/10.1186/s12933-017-0496-8

Hurtado-Roca, Y., Bueno, H., Fernandez-Ortiz, A., Ordovas, J.M., Ibañez, B., Fuster, V., Rodriguez-Artalejo, F. and Laclaustra, M., 2017. Oxidized LDL is associated with metabolic syndrome traits independently of central obesity and insulin resistance. *Diabetes*, **66**: 474-482. https://doi.org/10.2337/db16-0933

Isomaa, B.O., Almgren, P., Tuomi, T., Forsén, B., Lahti, K., Nissén, M., Taskinen, M.R. and Groop, L., 2001. Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabet. Care*, **24**: 683-689. https://doi.org/10.2337/diacare.24.4.683

Jia, W.P., Lu, J.X., Xiang, K.S., Bao, Y.Q., Lu, H.J. and Chen, L., 2003. Prediction of abdominal visceral obesity from body mass index, waist circumference and waist-hip ratio in Chinese adults: Receiver operating characteristic curves analysis. *Biomed. environ. Sci.*, **16**: 206-211.

Kidd, B.A., Hoffman, G., Zimmerman, N., Li, L., Morgan, J.W., Glowe, P.K., Botwin, G.J., Parekh, S., Babic, N., Doust, M.W. and Stock, G.B., 2016. Evaluation of direct-to-consumer low-volume lab tests in healthy adults. *J. clin. Invest.*, **126**: 1734-1744. https://doi.org/10.1172/JCI86318

Koumaré, A.T.K., Sakandé, L.P., Kabré, E., Sondé, I., Simporé, J. and Sakandé, J., 2015. Reference ranges of cholesterol sub-fractions in random healthy adults in Ouagadougou, *Burkina Faso*. *PLoS One*, **10**: e0116420. https://doi.org/10.1371/journal.pone.0116420

Laaksonen, D.E., Lakka, H.M., Salonen, J.T., Niskanen, L.K., Rauramaa, R. and Lakka, T.A., 2002. Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. *Diabet. Care*, **25**: 1612-1618. https://doi.org/10.2337/diacare.25.9.1612

Ladabaum, U., Mannalithara, A., Myer, P.A. and Singh, G., 2014. Obesity, abdominal obesity, physical activity, and caloric intake in US adults: 1988 to 2010. *Am. J. Med*., **127**: 717-727. https://doi.org/10.1016/j.amjmed.2014.02.026

McNeill, A.M., Rosamond, W.D., Girman, C.J., Golden, S.H., Schmidt, M.I., East, H.E., Ballantyne, C.M. and Heiss, G., 2005. The metabolic syndrome and 11-year risk of incident cardiovascular disease in the atherosclerosis risk in communities study. *Diabet. Care*, **28**: 385-390. https://doi.org/10.2337/diacare.28.2.385

Misra, A. and Khurana, L., 2008. Obesity and the metabolic syndrome in developing countries. *J. clin. Endocrinol. Metabol*., **93**: S9-S30. https://doi.org/10.1210/jc.2008-1595

Palaniappan, L., Carnethon, M. and Fortmann, S.P., 2003. Association between microalbuminuria and the metabolic syndrome: NHANES III. *Am. J. Hypertens*., **16**: 952-958. https://doi.org/10.1016/S0895-7061(03)01009-4

Rampal, S., Mahadeva, S., Guallar, E., Bulgiba, A., Mohamed, R., Rahmat, R., Arif, M.T. and Rampal, L., 2012. Ethnic differences in the prevalence of metabolic syndrome: Results from a multi-ethnic population-based survey in Malaysia. *PLoS One*, **7**: e46365. https://doi.org/10.1371/journal.pone.0046365

Ranasinghe, P., Cooray, D.N. and Jayawardena, R., 2015. The influence of family history of hypertension on disease prevalence and associated metabolic risk factors among Sri Lankan adults. *BMC Publ. Hlth.*, **15**: 576. https://doi.org/10.1186/s12889-015-1927-7

Smith, A.D., Crippa, A. and Woodcock, J., 2016. Physical activity and incident type 2 diabetes mellitus: A systematic review and dose-response meta-analysis of prospective cohort studies. *Diabetologia*, **59**: 2527-2245. https://doi.org/10.1007/s00125-016-4079-0

Suarez-Ortegón. M.F. and Aguilar-de Plata, C., 2016. Prevalence of metabolic syndrome in children aged 5-9 years from southwest Colombia: A cross-sectional study. *World J. Pediat.,* **12**: 477-483. https://doi.org/10.1007/s12519-016-0008-z

Szendroedi, J., Phielix, E. and Roden, M., 2012. The role of mitochondria in insulin resistance and type 2 diabetes mellitus. *Nat. Rev. Endocrinol*., **8**: 92-103. https://doi.org/10.1038/nrendo.2011.138

Tao, L.X., Yang, K. and Liu, K., 2016. Longitudinal Associations between triglycerides and metabolic syndrome components in a Beijing adult population, 2007-2012. *Int. J. med. Sci*., **13**: 445-450. https://doi.org/10.7150/ijms.14256

Tumova, J., Andel, M. and Trnka, J., 2016. Excess of free fatty acids as a cause of metabolic dysfunction in skeletal muscle. *Physiol. Res*., **65**: 193-207.

USFDA, 2014. *Self-monitoring blood glucose test systems for over-the-counter use*. Draft Guidance for Industry and Food and Drug Administration Staff. Food and Drug Administration, Department of Health and Human Services, USA. Available at: http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM380327.pdf (Accessed on March 03, 2019).

Vukovic, R., Zdravkovic, D., Mitrovic, K., Milenkovic, T., Todorovic, S., Vukovic, A. and Soldatovic, I., 2015. Metabolic syndrome in obese children and adolescents in Serbia: prevalence and risk factors. *J. Pediat. Endocrinol. Metabol*., **28**: 903-909. https://doi.org/10.1515/jpem-2014-0533

Wagner, A., Dallongeville, J., Haas, B., Ruidavets, J.B., Amouyel, P., Ferrières, J., Simon, C. and Arveiler, D., 2012. Sedentary behaviour, physical activity and dietary patterns are independently associated with the metabolic syndrome. *Diabet. Metab*., **38**: 428-435. https://doi.org/10.1016/j.diabet.2012.04.005

Warren, T.Y., Barry, V., Hooker, S.P., Sui, X., Church, T.S. and Blair, S.N., 2010. Sedentary behaviors increase risk of cardiovascular disease mortality in men. *Med. Sci. Sports Exerc*., **42**: 879-885. https://doi.org/10.1249/MSS.0b013e3181c3aa7e

Xiao, J., Shen, C., Chu, M.J., Gao, Y.X., Xu, G.F., Huang, J.P., Xu, Q.Q. and Cai, H., 2016. Physical activity and sedentary behavior associated with components of metabolic syndrome among people in rural China. *PLoS One*, **11**: e0147062. https://doi.org/10.1371/journal.pone.0147062

Yuzefovych, L.V., Musiyenko, S.I., Wilson, G.L. and Rachek, L.I., 2013. Mitochondrial DNA damage and dysfunction, and oxidative stress are associated with endoplasmic reticulum stress, protein degradation and apoptosis in high fat diet-induced insulin resistance mice. *PLoS One*, **8**: e54059. https://doi.org/10.1371/journal.pone.0054059

Zhang, H., Zhang, T., Li, S., Li, Y., Hussain, A., Fernandez, C., Harville, E., Bazzano, L.A., He, J. and Chen, W., 2015. Long-term impact of childhood adiposity on adult metabolic syndrome is modified by insulin resistance: The Bogalusa heart study. *Scient. Rep*., **5**: 17885. https://doi.org/10.1038/srep17885

Zimmet, P., Alberti, K.G.M., Kaufman, F., Tajima, N., Silink, M., Arslanian, S., Wong, G., Bennett, P., Shaw, J. and Caprio, S., 2007. The metabolic syndrome in children and adolescents–an IDF consensus report. *Pediat. Diabet*., **8**: 299-306. https://doi.org/10.1111/j.1399-5448.2007.00271.x

Zurlo, F., Larson, K., Bogardus, C. and Ravussin, E., 1990. Skeletal muscle metabolism is a major determinant of resting energy expenditure. *J. clin. Invest*., **86**: 1423-1227. https://doi.org/10.1172/JCI114857