A Study of Prevalence of Diabetes Mellitus, Prediabetes and Cardio Metabolic Profile among Rural Population in South India

Sethuram K[1], Uma M.A.[2], Srinivasa Rao[3]

ABSTRACT

Introduction: Diabetes and prediabetes are rapidly growing in India. Diabetes is the single most important risk factor for cardiovascular disease. As 72.2% of the Indian population resides in rural areas, the current study was carried to assess the prevalence of Diabetes Mellitus, prediabetes and cardio metabolic profile in a rural population.

Material and methods: A total of 300 people aged more than 18 years were included in this observational, community-based study. All the relevant parameters were documented in a structured study proforma. The following investigations were done in all subjects: fasting blood glucose, post prandial blood glucose, fasting lipid profile, electrocardiography and echocardiogram.

Results: The prevalence of diabetes was 37.33% and pre diabetes was 8.67% in the current study. Among diabetics mean age was 51.17 years and 43.69 years in prediabetics. Among diabetics 69 (69.6%) were males and 43 (38.4%) were females. Among the prediabetics 43 (38.4%) were males and 12 (46.2%) were females. Among diabetes patients mean Triglycerides (TGL) was 175.24 mg/dl. In this study 128 (42.7%) participants were overweight, 114 (38%) were obese, 85 (28.33%) were alcoholics, 44 (14.67%) were smokers.

Conclusion: Higher Total cholesterol, Triglycerides levels are associated with higher chance of prediabetes and diabetes. Increasing age is also a risk factor for prediabetes and diabetes. The prevalence of the diabetics and prediabetes is rising in rural population. Hence it is essential to create awareness about diabetes and accessibility to health care services among rural population.

Keywords: Age, Diabetes Mellitus, Prediabetes, Prevalence, Total Cholesterol, Triglycerides.

INTRODUCTION

Diabetes Mellitus (DM) remains as one of the impertinent global epidemics of the twenty-first century.[1] Diabetes mellitus is possibly reaching epidemic proportions in India.[2] There are large dissimilarities in diabetes prevalence between states in India.[3] As stated by a recent systematic review based on the statistics from ICMR-INDIAB, the overall prevalence of diabetes in 15 states of India was 7·3% (95% CI 7·0-7·5).[3] The etiology of diabetes in India is complex and includes genetic factors coupled with environmental impact such as obesity associated with rising standard of comfort, constant urban migration, and lifestyle changes.[2]

Prediabetes (intermediate hyperglycemia) is a high-risk state for diabetes that is defined by glycemic variables that are higher than normal, but lower than diabetes thresholds. 5-10% of people per year with prediabetes will headway to diabetes, with the same share converting back to normoglycaemia. Prevalence of prediabetes is growing worldwide, and authorities have estimated that more than 470 million people will have prediabetes by 2030.[4]

In spite of a clear association between diabetes and atherosclerotic vascular disease, the fundamental mechanisms that connect the two diseases are not clear. The current medical literature has highlighted the importance of non glycemic factors such as arterial hypertension, dyslipidemia in escalating atherosclerosis.[5]

Even though diabetes is now evident across all sections of society within India, there are very few studies reported from the rural population. Misra et al[6] in a review of diabetic studies in rural India found that prevalence of diabetes increased from 1.9% in 1994 to upwards of 12% in 2009. Increasing trend of Impaired fasting glucose (IFG) and Impaired glucose tolerance (IGT) has been observed in all parts of the India.[6] This pattern is alarming as 72.2% of the Indian population reside in rural areas with low income, limited resources and poor access to health services.[7] Hence the current study was carried to assess the prevalence of Diabetes Mellitus, Prediabetes and cardio metabolic profile in rural population of Kuppam.

MATERIAL AND METHODS

The current study was an observational, community-based study conducted in the Department of General medicine at P.E.S.I.M.S.R, Kuppam. All adult patients aged above 18 years who were willing to take part in the study in areas in and around Kuppam were considered as the study population. The data collection for the study was done from June 2017 to June 2018, for a period of 1 year.

Sampling technique: Every village having a population of 600 and situated within a radius of 5 km of PESIMSR was selected. Each village was considered as a cluster. Out

[1]Post Graduate Resident, Department of General Medicine, PESIMSR, [2]Associate Professor, Department of General Medicine, PESIMSR, [3]Professor and Head, Department of General Medicine, PESIMSR, Kuppam. Chittoor Dist, Andhra Pradesh, India.

Corresponding author: Dr. Uma.M.A., Associate Professor, Department of General Medicine, PES Institute of Medical Sciences and Research, Kuppam. 517425, Chittoor Dist, Andhra Pradesh, India.

How to cite this article: Sethuram K, Uma M.A., Srinivasa Rao. A study of prevalence of diabetes mellitus, prediabetes and cardio metabolic profile among rural population in South India. International Journal of Contemporary Medical Research 2019;6(3):C4-C9.

DOI: http://dx.doi.org/10.21276/ijcmr.2019.6.3.19

of nine such villages, four were selected by simple random sampling. In each selected village, by purposive sampling, 50 households were selected. All adults aged more than 18 years in the selected households were included in the study.

Inclusion Criteria

1. All adult patients aged 18 years residing in and around Kuppam.
2. People who are willing to take part in the study.

Exclusion criteria

Participants who refuse to participate in the study.

A total of 300 people were included in the study. All the relevant parameters were documented in a structured study proforma. After informed consent the following investigations were done on all study subjects: fasting blood glucose, post prandial blood glucose, fasting lipid profile, electrocardiography and echocardiogram.

STATISTICAL METHODS

Descriptive analysis was carried out by the mean and standard deviation for quantitative variables, frequency and proportion for categorical variables. All Quantitative variables were checked for a normal distribution within each category of an explanatory variable by using visual inspection of histograms and normality Q-Q plots. Shapiro-wilk test was also conducted to assess normal distribution. Shapiro wilk test *P* value of >0.05 was considered as a normal distribution. For normally distributed Quantitative parameters the mean values were compared between study groups using Independent sample t-test (2 groups) / ANOVA (>2 groups). If statistically significant difference was found in ANOVA, appropriate post -hoc test (LSD) was used to assess the statistical significance of pair wise comparisons. Categorical outcomes were compared between study groups using Chi square. *P* value < 0.05 was considered statistically significant. IBM SPSS version 22 was used for statistical analysis.[8]

RESULTS

This study was done to see the prevalence of Diabetes Mellitus and Prediabetes Mellitus and Cardiometabolic profile in rural Indian population. A total 300 people were included in the analysis. Among the study population 5 were

Parameter	Final diagnosis			*P* value
	Diabetes	Pre-diabetes	Normal	
Age (Mean ± SD)	**51.17 ± 10.9**	**43.69 ± 11.12**	**43.14 ± 11.26**	**<0.001**
Age (in years)				
18-25 (N=5)	0 (0%)	0 (0%)	5 (100%)	<0.001
26-45 (N=149)	39 (26.17%)	16 (10.73%)	94 (63.08%)	
46-65 (N=132)	62 (46.96%)	9 (6.818%)	61 (46.21%)	
>=66 (N=14)	11 (78.57%)	1 (7.142%)	2 (14.28%)	
Gender				
Male (N=164)	69 (42.07%)	14 (8.536%)	81 (49.39%)	0.165
Female (N=136)	43 (31.61%)	12 (8.823%)	81 (59.55%)	
Alcohol Abuse				
Yes (N=46)	17 (36.95%)	5 (10.86%)	24 (52.17%)	0.84
No (N=254)	95 (37.40%)	21 (8.267%)	138 (54.33%)	
Smoking				
Yes (N=24)	15 (62.5%)	0 (0%)	9 (37.5%)	*
No (N=276)	97 (35.14%)	26 (9.420%)	153 (55.43%)	
Body mass index				
Normal (N=58)	16 (27.58%)	2 (3.448%)	40 (68.96%)	0.04
Overweight(N=128)	45 (35.15%)	12 (9.375%)	71 (55.46%)	
Obese (N=114)	51 (44.73%)	12 (10.52%)	51 (44.73%)	
Fasting Lipid Profile				
TC (Mean ± SD)	183.69 ± 37.05	190 ± 37.31	171.45 ± 30.56	0.002
TGL (Mean ± SD)	175.24 ± 120.64	268.69 ± 250.45	157.47 ± 113.92	<0.001
HDL (Mean ± SD)	39.97 ± 8.7	39.31 ± 11.34	42.60 ± 10.10	0.050
LDL (Mean ± SD)	108.78 ± 33.94	110.96 ± 28.06	100.38 ± 24.75	0.04
IHD				
Yes (N=8)	4 (50%)	0 (0%)	4 (50%)	**
No (N=292)	108 (36.98%)	26 (8.904%)	158 (54.10%)	
ECG				
Normal (N=192)	59 (30.72%)	21 (10.93%)	112 (58.33%)	0.003
Borderline abnormality (N=68)	28 (41.17%)	4 (5.882%)	36 (52.94%)	
LVH (N=40)	25 (62.5%)	1 (2.5%)	14 (35%)	

TC- Total cholesterol, TGL-Triglycerides, HDL- High density lipoprotein, LDL- low density lipoprotein, IHD- ischemic heart disease, ECG- electrocardiogram, LVH- left ventricular hypertrophy. *No statistical test was applied- due to 0 subjects in the cells

Table-1: Risk factors for diabetes, pre-diabetes among the study population (N=300)

Parameter	Pre-diabetic (N=26)	Normal (N=162)	*P* value
Age (Mean ± SD)	43.69 ± 11.12	43.14 ± 11.26	<0.001
Age group(in years)			
18 to 25	0 (0%)	5 (3.086%)	0.60
26-45	16 (61.53%)	94 (58.02%)	
46-65	9 (34.61%)	61 (37.65%)	
>=66	1 (3.846%)	2 (1.234%)	
Gender			
Male	14 (53.8%)	81 (50%)	0.716
Female	12 (46.2%)	81 (50%)	
Alcohol Abuse			
Yes	6 (23.1%)	54 (33.3%)	0.298
No	20 (76.9%)	108 (66.7%)	
Smoking			
Yes	1 (3.8%)	23 (14.2%)	0.142
No	25 (96.2%)	139 (85.8%)	
BMI			
Normal	2 (7.692%)	40 (24.69%)	0.11
Overweight	12 (46.15%)	71 (43.82%)	
Obese	12 (46.15%)	51 (31.48%)	
Fasting Lipid Profile			
TC (Mean ± SD)	190 ± 37.31	171.45 ± 30.56	0.006
TGL (Mean ± SD)	268.69 ± 250.45	157.47 ± 113.92	<0.001
HDL (Mean ± SD)	39.31 ± 11.34	42.6 ± 10.1	.131
LDL (Mean ± SD)	110.96 ± 28.06	100.38 ± 24.75	.062
IHD			
Yes	0 (0%)	4 (2.5%)	*
No	26 (100%)	158 (97.5%)	
ECG			
Normal (N=126)	21 (80.8%)	112 (69.1%)	0.457
Borderline abnormality (N=126)	4 (15.4%)	36 (22.2%)	
LVH (N=126)	1 (3.8%)	14 (8.6%)	

*No statistical test was applied- due to 0 subjects in the cells. TC- Total cholesterol, TGL-Triglycerides, HDL- High density lipoprotein, LDL- low density lipoprotein, IHD- ischemic heart disease, ECG- electrocardiogram, LVH- left ventricular hypertrophy.

Table-2: Comparision of Risk factors for prediabetes with normal among the study population (N=188)

in 18-25 (1.7%) age group, 149 were in 26-45 (49.7) age group,132 were in 46-65 (44%) age group and 14 were >=66 (4.7%) age group people .The number of males 164 (54.67%) were more than the number of females 136 (45.33%) and most participants were married 272 (97.49%). Among the study population 33 (11%) were farmers, 143 (47.7%) were professional, 83 (27.7%) were house wives and 41 (13.7%) were others.

Among the study population 85 (28.33%) were alcoholics, 44 (14.67%) were smokers. 40 (13.33%) were vegetarian and 260 (86.67%) were non-vegetarian. Among the study population 257 (85.67%) were physically active. 69 (23%) had previous history of diabetes and 53 (17.67%) had hypertension. In this study 128 (42.7%) participants were overweight (BMI-24-29.9), and 114 (38%) were obese BMI >=30). 112 (37.33%) were diabetics, 26 (8.67%) were pre-diabetics, and 162 (54%) were nondiabetic. Among diabetes patients mean age was 51.17 years and it was 43.69 years in prediabetes patients. The mean difference was statistically significant (*P* value<0.05).

Among diabetes patients 69 (69.6%) were males and 43 (38.4%) were females. Among the prediabetes patients 43 (38.4%) were males and 12 (46.2%) were females. The difference in the proportion of gender between diabetes and prediabetes patients was statistically significant (*P* value<0.05). Among diabetes patients mean Triglycerides (TGL) was 175.24 mg/dl. Among the prediabetes patients it was 268.69 mg/dl. The mean difference of TGL between diabetes and prediabetes patients was statistically significant (*P* value<0.05). Among diabetes patients 4 (3.6%) had ischemic heart disease (IHD). In the prediabetes group there were no IHD patients. Among diabetes patients 59 (52.7%), had normal ECG, 28 (25%) had borderline abnormality ECG and 25 (22.3%) had left ventricular hypertrophy (LVH). Among the prediabetes patients 21 (80.8%) had normal ECG, 4 (15.4%) had borderline abnormality and 1 (3.8%) had LVH. The difference in the proportion of ECG between diabetes and prediabetes patients was statistically significant (*P* value<0.05).The risk factors for diabetes, pre-diabetes among the study population is shown in table 1.

Among the pre-diabetic patients mean age was 43.69 years, and 43.14 years in normal respectively. The mean age difference was statistically significant (*P* value<0.05). Among 18-25 years age group all 5 (3.08%) were normal. Among the 26-45 years age group, 16 (61.53%) were pre-diabetic, 94 (58.02%) were normal. Among the 46-65 years age group, 9 (3.84%) were pre-diabetic, and 61 (37.65%) were normal. Among >=66 years age people, 1 (3.84%) was pre-diabetic, and 2 (1.23%) were normal. The difference in the proportion of final diagnosis across different age groups was statistically not significant (*P* value>0.05). The risk factors for prediabetes are depicted in table 2.

DISCUSSION

Diabetes is rapidly growing to be a budding epidemic in India with more than 62 million people presently identified with the disease.[2] Prediabetes is a potential state for developing diabetes. Individuals with prediabetes and diabetes have the worst clinical and biochemical characteristics related to increased cardiovascular risk and the highest frequency of metabolic syndrome.[4] Moreover, the prevalence of diabetes and prediabetes is increasing even among the rural population due to fast lifestyle changes.[7] Considering the high mortality rate and morbidity due to diabetes, it is necessary to assess the prevalence of this devastating condition among the rural population. The current study was carried out to assess the prevalence of diabetes and prediabetes and the cardio metabolic risk profiles among the rural population in Kuppam.

In the present study comprising of 300 persons representing the rural population of Kuppam,149 (49.67%) participants belong to the age group 26-45 followed by age group 46-65 with 132 (45.33%) participants. The number of males 164(54.67%) was more than the number of females 136(45.33%). Most participants 272(97.49%), were married. In the study by Chiwanga F. S. et al[9] the highest number of participants belonged to the age group of 30-39 years followed by the age group of 40 -49. The number of female participants (80, 51.6%) was more than males (75, 48.4%). In the study by Mohamed S. F. et al[10] it was found that majority of the participants 46.1% were in the age group of 18–29 followed by 32.7% in the age group 30–44 and then 15.9% in the age group 45–59 years of age. 66.1% of participants were either married or were living together, and about 51% were females. The significant difference in the characteristics of the study population can be attributed to the health seeking behavior of different study populations and setting.

Diabetes is a complex disease of multi factorial origin.[7] Diabetes is the single most important risk factor for cardiovascular disease.[5] In the present study 69 (23%) participants had postprandial plasma glucose of 200mg/dl and above. The prevalence of diabetes was 37.33% in the current study. This is far high compared to other studies conducted in a rural population in India.[6,11] This can be attributed to selection bias. Globally according to the current Centre for disease control (CDC) report from 1980–2014, the age-adjusted incidence of diagnosed diabetes nearly doubled from 3.5 to 6.6 per 1000 population. Between 1990 and 2008, rates more than doubled from 3.8 to 8.5 per 1000 and increases were seen in both sexes. However, from 2008–2014, age-adjusted incidence significantly declined from 8.5 to 6.6 per 1000.[12]

According to a recent systematic review based on the data from Indian Council of Medical Research-India Diabetes (ICMR-INDIAB), the overall prevalence of diabetes in 15 states of India was 7·3%.[3] The prevalence of diabetes and was higher in urban areas (11·2%, 10·6-11·8) than in rural areas (5·2%, 4·9-5·4; p<0·0001). Ramachandran C et al[11] reported nearly a three-fold increase in age- and sex-adjusted prevalence of diabetes (from 2.20% to 6.36%). Recent studies have shown a rapid conversion of impaired glucose tolerance to diabetes in the southern states of India, where the prevalence of diabetes among adults has reached approximately 20% in urban populations and approximately 10% in rural populations.[13]

Prediabetes

The postprandial plasma glucose between 140 and 200 mg/dl was found among 69 (23%) participants. The prevalence of prediabetes was 8.67% in the current study. Dysfunction of β-cells is a main factor across the progression from prediabetes to diabetes. After the progression from normal glucose tolerance to abnormal glucose tolerance, postprandial blood glucose levels increase initially. Thereafter, fasting hyperglycemia may develop as the suppression of hepatic gluconeogenesis fails.[14] According to a recent systematic review based on the data from ICMR-INDIAB, the prevalence of prediabetes varied across regions. The overall prevalence of prediabetes in all 15 states was 10·3% (10·0–10·6) and the prevalence of impaired fasting glucose was generally higher than the prevalence of impaired glucose tolerance.[3] In the study by Ramachandran C et al[11] the prevalence of IGT did not change significantly (7.44% in 1989 vs. 7.18% in 2003) among the rural population.

Cardio-metabolic risk profile

Cardiovascular disease is the leading cause of morbidity and mortality among individuals with Type 2 diabetes, accounting for 68% of all diabetic deaths.[2] Between 1997–2005, NHIS data indicate that the number of persons aged ≥35 years with diagnosed diabetes who reported having CVD increased 36%.[12] In the current study, it was found that diabetes mellitus was associated with abnormal ECG findings. Higher the TLC and TG, higher was the chance of prediabetes and diabetes. The increase in age was also a risk factor for prediabetes and diabetes. In the current study 128 (44.29%) participants had overweight and 114(39.45%) participants had obesity. Only 47(16.26%) participants had the normal weight. Overall, the majority of the participants were either overweight or obese. A recent nationwide study done by Luhar S et al[15] in rural areas in India found around 15%- 32% increases in overweight/obesity prevalence among all individuals from 1998-2016, irrespective of Socioeconomic patterning. Sengupta A et al[16] in a study among women in various states across India documented

that overweight problem has started expanding from urban and well-off women to the poor and rural people, while the rural-urban and rich-poor difference has disappeared. The shift towards a diet higher in fat and meat and lower in carbohydrates and fiber, together with the shift towards less onerous physical activity, carries unwanted nutritional and health effects. This was in agreement with the current study where the majority of the participants (86%) were non-vegetarians. Moreover, it has generally been observed that there has been a remarkable shift in an occupational structure in lower income countries from agricultural labour towards employment in manufacturing and services, resulting in a reduction in energy expenditure and a consequent increase in obesity.[17]

Obesity and activity are closely linked with adult-onset diabetes.[18] In obese individuals, the amount of non-esterified fatty acids, glycerol, hormones, cytokines, pro-inflammatory markers, and other substances that are involved in the development of insulin resistance, is increased.[18] But our study could not find a significant association between BMI with either diabetes compared to prediabetes or diabetes compared to normal. Twig G et al[19] in a study reported that healthy metabolic profile and the absence of diabetes risk factors do not protect young adults from incident diabetes associated with overweight and obesity.[19] Varying results were obtained from the studies linking diabetes and obesity. Adjusted diabetes risk was reported to be unchanged[20], 4-fold higher[21], or 13-fold higher[21] in metabolically healthy (MH)-obese compared with MH-normal weight individuals.

Limitations

This was an observational study; thus, the observed association cannot be interpreted as causal inferences.

Purposive sampling technique was employed for the study which is not a true representation of the general population.

The stratified random sampling was not employed for a community based study. Hence, the study cannot be generalized to the rest of the population which has similar settings.

Recommendations

A large scale prospective study is recommended to know the risk factors among the rural population leading to diabetes and other cardiometabolic disorders. The present study has considered the evidence regarding the association between diabetes and certain other risk factors to establish the correlation between these factors. A long term cohort study or randomized trials are recommended. The study population must also be stratified and randomized in order for the study sample to truly represent the population. The knowledge must be used to improve the overall quality of life in the rural areas.

CONCLUSION

This community-based cross sectional study was conducted in rural area of Kuppam to know the cardio metabolic risk factors among the persons with diabetes and the prediabetes in the population. The prevalence of the diabetics was found to be 112 (37.33%) and the prevalence of pre diabetes was found to be 26 (8.67%). The prevalence rate was found to be very high**.** Among diabetics, the mean-age, TC, TGL, HDL, LDL and IHD were significant risk factors. Among the prediabetes patients, mean-age, TC, FLP, TGL was statistically significant risk factors. Because of the considerable disparity in the availability and affordability of diabetes care, as well as low awareness of the disease it is high time to give attention to the people in rural areas of India.

REFERENCES

1. Bolignano D, Cernaro V, Gembillo G, Baggetta R, Buemi M, D'Arrigo G. Antioxidant agents for delaying diabetic kidney disease progression: A systematic review and meta-analysis. PLoS One. 2017;12:e0178699.
2. Kaveeshwar SA, Cornwall J. The current state of diabetes mellitus in India. Australas Med J. 2014;7:45–8.
3. Anjana RM, Deepa M, Pradeepa R, Mahanta J, Narain K, Das HK, et al.; ICMR–INDIAB Collaborative Study Group. Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR-INDIAB population-based cross-sectional study. Lancet Diabetes Endocrinol. 2017;5:585–96.
4. Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M. Prediabetes: a high-risk state for diabetes development. Lancet. 2012;379:2279–90.
5. Milicevic Z, Raz I, Beattie SD, Campaigne BN, Sarwat S, Gromniak E, et al. Natural history of cardiovascular disease in patients with diabetes: role of hyperglycemia. Diabetes Care. 2008;31:S155-60.
6. Misra P, Upadhyay RP, Misra A, Anand K. A review of the epidemiology of diabetes in rural India. Diabetes Res Clin Pract. 2011;92:303–11.
7. Little M, Humphries S, Patel K, Dewey C. Decoding the Type 2 Diabetes Epidemic in Rural India. Med Anthropol. 2017;36: 96–110.
8. Machines IB. IBM SPSS Statistics for Windows, Version 22.0. NY: IBM Corp Armonk; 2013.
9. Chiwanga FS, Njelekela MA, Diamond MB, Bajunirwe F, Guwatudde D, Nankya-Mutyoba J, et al. Urban and rural prevalence of diabetes and pre-diabetes and risk factors associated with diabetes in Tanzania and Uganda. Glob Health Action. 2016;9:31440.
10. Mohamed SF, Mwangi M, Mutua MK, Kibachio J, Hussein A, Ndegwa Z, et al. Prevalence and factors associated with pre-diabetes and diabetes mellitus in Kenya: results from a national survey. BMC Public Health. 2018;18:1215.
11. Ramachandran A, Snehalatha C, Baskar AD, Mary S, Kumar CK, Selvam S, et al. Temporal changes in prevalence of diabetes and impaired glucose tolerance associated with lifestyle transition occurring in the rural population in India. Diabetologia. 2004;47:860–5.
12. Bhupathiraju SN, Hu FB. Epidemiology of Obesity and Diabetes and Their Cardiovascular Complications. Circ Res. 2016;118:1723–35.
13. Ramachandran A, Chamukuttan S. Current scenario of diabetes in India 2009. 18-28 p.
14. Porte D Jr. Banting lecture 1990. Beta-cells in type II

diabetes mellitus. Diabetes. 1991;40:166–80.
15. Luhar S, Mallinson PA, Clarke L, Kinra S. Trends in the socioeconomic patterning of overweight/obesity in India: a repeated cross-sectional study using nationally representative data. BMJ Open. 2018;8:e023935.
16. Sengupta A, Angeli F, Syamala TS, Dagnelie PC, van Schayck CP. Overweight and obesity prevalence among Indian women by place of residence and socio-economic status: contrasting patterns from 'underweight states' and 'overweight states' of India. Soc Sci Med. 2015;138:161–9.
17. Popkin BM. Nutrition in transition: the changing global nutrition challenge. Asia Pac J Clin Nutr. 2001;10:S13–8.
18. Al-Goblan AS, Al-Alfi MA, Khan MZ. Mechanism linking diabetes mellitus and obesity. Diabetes Metab Syndr Obes. 2014;7:587–91.
19. Twig G, Afek A, Derazne E, Tzur D, Cukierman-Yaffe T, Gerstein HC, et al. Diabetes risk among overweight and obese metabolically healthy young adults. Diabetes Care. 2014;37:2989–95.
20. Appleton SL, Seaborn CJ, Visvanathan R, Hill CL, Gill TK, Taylor AW, et al.; North West Adelaide Health Study Team. Diabetes and cardiovascular disease outcomes in the metabolically healthy obese phenotype: a cohort study. Diabetes Care. 2013;36:2388–94.
21. Aung K, Lorenzo C, Hinojosa MA, Haffner SM. Risk of developing diabetes and cardiovascular disease in metabolically unhealthy normal-weight and metabolically healthy obese individuals. J Clin Endocrinol Metab. 2014;99:462–8.

Source of Support: Nil; **Conflict of Interest:** None

Submitted: 01-02-2019; **Accepted:** 16-02-2019; **Published:** 20-03-2019