Journal of Endocrinology, Metabolism and Diabetes of South Africa 2016; 21(2):20–25
http://dx.doi.org/10.1080/16089677.2016.1198112

JEMDSA
ISSN 1608-9677 EISSN 2220-1009

RESEARCH

Effects of self-monitoring of blood glucose on diabetes control in a resource-limited diabetic clinic

S Pillay[a]* and C Aldous[b]

[a]*Department of Internal Medicine, Edendale Hospital, Pietermaritzburg, South Africa*
[b]*School of Clinical Medicine, University of KwaZulu-Natal, Durban, South Africa*
Corresponding author, email: drspillay@iafrica.com

Background: Diabetes mellitus places an enormous burden upon both patients and countries' health systems. Integral to achieving control is patients assuming responsibility for their condition. Self-monitoring of blood glucose (SMBG) can serve as a powerful tool modifying lifestyle behaviour and can aid in achieving optimal control.
Methods: This study assessed the effect on diabetes control in patients who received glucometers and education over 12 months. This data was analysed at baseline, 6 and 12 months.
Results: Glycaemic control improved significantly between baseline, 6 and 12 months (HbA1c% 12.29 ± 3.17 vs. 11.16 ± 3.09 vs. ±10.68 ± 3.10, respectively). The number of patients achieving target glycaemic control increased substantially while the number of patients achieving target total cholesterol and triglyceride levels improved at six months. Mean HDL cholesterol increased significantly between baseline and 12 months (1.20 ± 0.42 vs. 1.31 ± 0.40, respectively; *p*-value 0.0095). The mean BMI of male patients in the study increased between 6 and 121 months (27.59 ± 6.42 vs. 31.90 ± 8.85, respectively, $p = 0.0012$) and between baseline and 12 months (27.64 ± 6.13 vs. 31.90 ± 8.85, respectively, $p = 0.0012$).
Conclusion: This study demonstrated that the introduction of SMBG and patient education, within this resource-limited clinic setting, had beneficial effects on diabetes control; however, obesity remains an obstacle to optimal control.

Keywords: BMI, diabetes control, diabetes mellitus, glycaemic control, obesity, patient education, resource-limited clinic, self-monitoring of blood glucose

Introduction

Diabetes mellitus (DM) is increasing globally.[1] Optimal diabetic control for most patients has proved elusive in studies in South Africa.[2–3] Good glycaemic control is vitally important in reducing diabetic-related morbidity and mortality.[4] Integral to achieving optimal diabetic control is empowering the diabetic patient to take responsibility for his/her medical condition. Patient education is crucial in this process of improving control.

Self-monitoring of blood glucose (SMBG) helps patients make informed decisions regarding their dosage of medication and helps them decide on whether they need to present urgently to their healthcare professional. Self-monitoring can serve as a powerful tool for modifying lifestyle behaviour, thereby aiding in achieving goals towards optimal control. All diabetic patients should ideally have access to their own glucometer but barriers to this include limited resources, poverty and unemployment in developing countries. A further problem encountered is patient anxiety regarding pain associated with finger-prick testing.[5]

Studies on the benefits of SMBG have been conflicting. Patrick *et al.*[6] found no definite evidence that home blood glucose monitoring improved blood glucose control in his cohort of type 2 diabetic patients. However, Guerc *et al.*,[7] in a larger study, showed definite evidence that home blood glucose monitoring improved metabolic control in diabetic patients. This benefit in controlling blood sugar with SMBG was also seen in a later study conducted by McAndrew *et al.*[8] Both the DiGEM study[9] and the ESMON study[10] found no clear benefit from SMBG on glycaemic control if SMBG was not accompanied by adequate patient education and training with regard to the steps to be taken when readings are either high or low in respect of medication dosages, exercise and dietary intake.

Our study involved the distribution of glucometers to diabetic patients on either insulin monotherapy or a combination of insulin and oral antidiabetics, together with extensive patient education on the use of the glucometer and directions on what to do in the event of hypo- or hyperglycaemia with regard to diet, exercise and medication adjustment. Clinical and biochemical variables of those patients who received glucometers were analysed retrospectively over a one-year period.

Methods

Edendale Hospital is a regional hospital situated in the KwaZulu-Natal midlands. Accu-chek® glucometers (Roche Diagnostics, Switzerland) were donated to the hospital and stored in the pharmacy for safekeeping. The diabetic clinic at this hospital started issuing these glucometers to all patients on any combination of insulin therapy from 1 February 2013. Detailed records of all glucometers issued were kept by the pharmacy. On receiving the glucometer, the patient returned to the clinic where our diabetic nurses/educators trained the patient on their machines. Patients were educated on frequency of testing, signs and symptoms of hypo- and hyperglycaemia and record keeping of blood glucose (BG) readings together with directions on the steps to follow in the event of high or low BG reading in terms of medication dose, dietary intake and exercise as well as when to report to a healthcare institution. All patients on two or more insulin injections per day were advised to do SMBG at least three times a day while patients on once-daily insulin were advised to do SMBG once daily.

Table 1: Description of patient population

Factor	Type 1 DM (*n* = 59)	Type 2 DM (*n* = 142)	Total (*n* = 201)
Gender			
Male	20	36	56 (27.86%)
Female	39	106	145 (72.14%)
Mean age (years)	34.3 ± 2.09	55.4 ± 0.95	49.17 ± 16.08
Number of patients with HIV infection	22	38	60 (29.85%)
Lifestyle modification			
Diet	42	94	136 (67.66%)
Exercise	35	63	98 (48.76%)
Number of patients unemployed	54	120	174 (86.57%)
Number of patients with hypertension	22	115	137 (68.16%)
Duration of DM (years)	7.6 ± 8.6	9.8 ± 6.9	9.1 ± 7.5

Note: *n = number of patients.*

During the time period when glucometers were handed out, transformation of the diabetic clinic was being carried out. A multifaceted approach was being employed at the clinic to improve diabetes control. This approach targeted both patients and the attending clinicians. Extensive patient education was being conducted by a fully operational multidisciplinary team whilst clinicians were being trained on local SEMDSA diabetes guidelines. A comprehensive diabetes datasheet was designed and introduced into the clinic to ensure standardisation in the approach and management of all diabetic patients.

This study assessed the effect on diabetes control in those patients who received glucometers over 12 months. Data on all patients who received glucometers from 1 February 2013 to 31 January 2015 were analysed. This entailed a retrospective chart review comparing the following variables in patients who received glucometers.

- At baseline, 6 and 12 months
  - Glycosylated haemoglobin (HbA1c %)
  - Blood pressure (BP): mmHg
  - BMI (kg/m^2)
  - Waist circumference (cm)
  - Waist-to-height ratio (WTHR)
  - Total cholesterol and triglycerides (mmol/l)
  - Low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol (mmol/l)
  - Glycosuria and proteinuria (using Makromed® urine dipsticks from Denmark)

The data collection was approved by the UMgungundlovu Health Ethics Review Board (UHERB) and the Biomedical Research Ethics Committee (BREC).

Results

A total of 201 patients received glucometers during the study period. The majority of these patients had type 2 versus type 1 DM (142 vs. 59, respectively). Table 1 provides a comparison between the demographics of the type 1 and type 2 patients. The majority (61.7%) of HIV-infected patients were not on antiretroviral therapy.

Table 2 demonstrates the changes noted in the various clinical and biochemical variables from baseline to 12 months within the entire group of diabetic patients. The mean HbA1c together with the number of patients achieving target glycaemic control, total cholesterol, triglyceride and LDL cholesterol levels improved within the first six months. This positive effect on glycaemic control persisted throughout the year following patients receiving their glucometers. There was an overall improvement in the HDL cholesterol level between baseline and one year. The number of patients achieving target blood pressure decreased significantly throughout the study period.

When the data were separated further into type 1 and type 2, it was noted that the trend of the beneficial effect on mean HbA1c and the number of patients achieving target glycaemic control persisted in both the type 1 and type 2 diabetic patients (Tables 3 and 4).

Within the type 2 patient cohort there was a significant improvement noted in the first six months in mean triglyceride, LDL cholesterol levels, numbers of patients achieving target triglyceride levels and the number of patients having urine dipstick proteinuria (Table 4).

Discussion

DM is a complicated disease with life-threatening sequelae. Control of DM requires a multifaceted approach that includes a variety of treatment modalities ranging from patient education to a multidisciplinary treatment team, appropriate therapeutics and lifestyle changes. A multifaceted approach to diabetes care was assessed in a previous study conducted at this resource-limited clinic and was found to have beneficial effects on diabetes control.[19] The implementation of SMBG into our clinic was assessed over a two-year period to determine whether the addition of SMBG had a positive effect on diabetes control in this South African setting.

Only a few diabetic patients in developing countries have access to SMBG due to limited resources. Glucometers together with the testing strips are expensive so SMBG is a scarce commodity in developing countries. According to the latest statistics provided by the IDF, 77% of diabetes patients live in low- and middle-income countries[1] while Pillay *et al*. have shown that the majority of patients in the public healthcare sector in KwaZulu-Natal are

Table 2: Changes in clinical and biochemical characteristics from baseline to 12 months for combined type 1 and type 2 patients

Factor	Baseline	6 months	12 months	Baseline -> 6 months *p*-value*	6 months -> 12 months *p*-value*	Baseline -> 12 months *p*-value*
Mean						
Systolic BP (mmHg)	131.30 ± 24.60	131.40 ± 22.80	133.50 ± 25.10	0.9464 [2]	0.4018 [2]	0.3814 [2]
Diastolic BP (mmHg)	79.60 ± 13.80	79.40 ± 14.40	80.60 ± 13.90	0.8666 [2]	0.4109 [2]	0.4984 [2]
Number of patients with BP ≤ 140/80 mmHg	95	93	71	0.8159 [1]	0.0084 [1]	0.0151 [1]
Mean HbA1c, %	12.29 ± 3.17	11.16 ± 3.09	10.68 ± 3.10	0.0003 [2]	0.1278 [2]	< 0.0001 [2]
Number of patients with HbA1c ≤ 7, %	9	28	40	0.0012 [1]	0.0835 [1]	< 0.0001 [1]
Mean total cholesterol (mmol/l)	4.58 ± 1.28	4.39 ± 1.27	4.35 ± 1.28	0.1657 [2]	0.8237 [2]	0.1118 [2]
Mean triglyceride (mmol/l)	1.96 ± 1.31	1.86 ± 1.66	1.81 ± 1.13	0.5184 [2]	0.7733 [2]	0.2642 [2]
Mean HDL cholesterol (mmol/l)	1.20 ± 0.42	1.24 ± 0.37	1.31 ± 0.40	0.2712 [2]	0.1149 [2]	0.0095 [2]
Mean LDL cholesterol (mmol/l)	2.45 ± 1.08	2.19 ± 0.95	2.36 ± 1.14	0.0548 [2]	0.1736 [2]	0.5610 [2]
Number of patients with:						
Total cholesterol < 4.5 mmol/l	94	113	105	0.0545 [1]	0.7405 [1]	0.1160 [1]
Triglyceride < 1.7 mmol/l	87	107	94	0.0422 [1]	0.2998 [1]	0.3255 [1]
Mean waist circumference (cm)	104.74 ± 16.96	102.77 ± 19.22	103.99 ± 16.51	0.2960 [2]	0.4496 [2]	0.6744 [2]
Mean BMI (kg/m^2)						
Males	27.64 ± 6.13	27.59 ± 6.42	31.90 ± 8.85	0.9706 [2]	0.0012 [2]	0.0012 [2]
Females	33.81 ± 7.45	34.04 ± 7.56	33.78 ± 9.13	0.8069 [2]	0.8021 [2]	0.9693 [2]
Number of patients with WTHR < 0.5	17	22	18	0.3488 [1]	0.6444 [1]	0.6466 [1]
Number of patients with:						
Glycosuria	103	80	92	0.0289 [1]	0.0391 [1]	0.9483 [1]
Proteinuria	26	28	22	0.5548 [1]	0.5330 [1]	0.8374 [1]

*[1] Chi-square; [2] Student's t-test.

diagnosed and have treatment initiated at their local healthcare clinics rather than at hospital level.[11] Interventions need to be implemented to help stem the tide of this diabetic pandemic. These interventions need to start at the community level, extending through local healthcare clinics and into district and regional hospitals. This is where the real need exists and this is where any difference made could translate into improvements in the entire process. Governments are recognising that non-communicable diseases (NCDs) need urgent attention to prevent the economies of these developing countries being crippled by the wave of NCDs. Partnerships need to be brokered between pharmaceutical companies and government to ensure diabetic patients receive glucometers and testing strips at discounted rates. Any improvement in diabetes control with SMBG would translate into improved long-term patient outcomes and decrease the economic burden for the country as a whole.

Both DM and hyperlipidaemia are regarded as risk factors for cardiovascular morbidity and mortality.[12–13] We have shown that within this cohort of patients who received glucometers, the introduction of SMBG in this resource-limited setting had definite benefits in improving glycaemic control in the first year. The UKPDS study demonstrated that a 1% decrease in HBA1c translates into a 37% decrease in micro-vascular complications.[4] Our study showed both a significant drop in HbA1c and an increase in the number of patients achieving target glycaemic control at both 6 and 12 months. This improvement in glycaemic control was coupled to a decrease in the number of patients with urine dipstick findings of glycosuria. At six months, there was a definite improvement in the number of patients achieving target total cholesterol, triglyceride and LDL cholesterol levels. Although there was an improvement in mean LDL cholesterol levels, these levels were still well above the recommended level of 1.8 mmol/l.[14] The majority of patients (73.13%) were on statin therapy. This statin therapy was optimised based on the lipogram results during the study. The mean HDL level increased substantially between baseline and 12 months. This is promising as the Framingham study noted that HDL cholesterol was a protective factor in coronary artery disease (CAD)[20] while Gordon *et al.* demonstrated a 2–3% decrease in CAD risk for every 10% decrease

Table 3: Changes in clinical and biochemical characteristics from baseline to 12 months within the type 1 DM cohort

Factor	Baseline	6 months	12 months	Baseline -> 6 months *p*-value*	6 months -> 12 months *p*-value*	Baseline -> 12 months *p*-value*
Mean						
Systolic BP (mmHg)	121.2 ± 17.9	124.0 ± 21.1	125.3 ± 20.4	0.4549 [2]	0.7445 [2]	0.2749 [2]
Diastolic BP (mmHg)	75.6 ± 12.2	76.3 ± 13.4	79.6 ± 13.2	0.7691 [2]	0.2047 [2]	0.1066 [2]
Number of patients with BP ≤ 140/80 mmHg	32	32	25	1.000 [1]	0.5298 [1]	0.5298 [1]
Mean HbA1c, %	12.57 ± 3.68	11.26 ± 3.64	10.97 ± 3.77	0.0575 [2]	0.6834 [2]	0.0245 [2]
Number of patients with HbA1c ≤ 7, %	3	12	13	0.0093 [1]	0.7407 [1]	0.0038 [1]
Mean total cholesterol (mmol/l)	4.42 ± 1.22	4.36 ± 1.66	4.41 ± 1.69	0.8161 [2]	0.8629 [2]	0.9739 [2]
Mean triglyceride (mmol/l)	1.44 ± 0.96	1.79 ± 2.57	1.31 ± 0.85	0.3710 [2]	0.2111 [2]	0.4625 [2]
Mean HDL cholesterol (mmol/l)	1.25 ± 0.40	1.29 ± 0.36	1.35 ± 0.37	0.5532 [2]	0.4742 [2]	0.1951 [2]
Mean LDL cholesterol (mmol/l)	2.58 ± 1.31	2.40 ± 1.17	2.42 ± 1.17	0.5937 [2]	0.9298 [2]	0.6352 [2]
Number of patients with:						
Total cholesterol < 4.5 mmol/l	29	32	31	0.5385 [1]	0.9394 [1]	0.5919 [1]
Triglyceride < 1.7 mmol/l	35	39	35	0.4518 [1]	0.4518 [1]	1.0000 [1]
Mean waist circumference (cm)	94.29 ± 15.49	90.90 ± 18.70	94.66 ± 16.74	0.3064 [2]	0.2920 [2]	0.9092 [2]
Mean BMI (kg/m^2)						
Males	25.32 ± 6.07	26.04 ± 6.62	25.64 ± 6.10	0.7277 [2]	0.8501 [2]	0.8782 [2]
Females	30.22 ± 6.58	30.36 ± 6.49	29.43 ± 6.54	0.9257 [2]	0.5598 [2]	0.6217 [2]
Number of patients with WTHR < 0.5	10	13	9	0.5451 [1]	0.6216 [1]	0.9300 [1]
Number of patients with:						
Glycosuria	29	25	28	0.5071 [1]	0.2430 [1]	0.5962 [1]

*[1] Chi-square; [2] Student's t-test.

in HDL cholesterol level.[21] The increased trend in obesity and unhealthy eating habits could possibly be related to the low numbers of patients achieving lipid control.

The UKPDS study found that control of blood pressure in diabetic patients was essential in preventing long-term diabetes complications.[4] Our patients demonstrated neither a substantial improvement, nor worsening of their overall blood pressures; however, there was a significant decrease in the number of patients achieving target blood pressures at the one-year mark. Part of our multifaceted approach to diabetes care entailed reviewing the patients' blood pressures and optimising their antihypertensive medications. This is a worrying trend and more emphasis needs to be placed on attaining optimal blood pressure control as outlined by local hypertension guidelines. The high prevalence of obesity together with worsening of BMI noticed in male patients within this cohort could possibly explain this phenomenon.

Globally obesity remains a constant obstacle to the development of and successful management of DM.[1,15] South African women have the highest prevalence of obesity in sub-Saharan Africa.[16] Using either a body mass index of ≥ 30 kg/m^2 or increased waist circumferences (≥ 86 cm in males and ≥ 92 cm in females)[17] as indicators of obesity, this study showed that the prevalence of obesity in our female patients remained high throughout the study. Male patients, however, showed a significant trend towards developing obesity during the study. This can possibly be attributed to unhealthy eating choices often associated with poverty, as the majority of our patients were unemployed, or increased doses of insulin therapy. A WTHR of > 0.5 is an excellent indicator of obesity and adverse cardiovascular outcomes.[18] Only a minority of the study patients managed to achieve the target WTHR of < 0.5, again emphasising the problem of the global obesity pandemic.

Our study showed definite benefit in those patients performing SMBG. The diabetic patients at resource-limited healthcare clinics could benefit from receiving glucometers together with appropriate education on its use.

Now that the roll-out of glucometers is well on its way in the clinic, the next phase of this process is to introduce a computer installed with the appropriate software to upload SMBG readings from the glucometer into the clinic's database and have it printed for the

Table 4: Changes in clinical and biochemical characteristics from baseline to 12 months within the type 2 DM cohort

Factor	Baseline	6 months	12 months	Baseline -> 6 months *p*-value*	6 months -> 12 months *p*-value*	Baseline -> 12 months *p*-value*
Mean						
Systolic BP (mmHg)	135.3 ± 25.8	134.5 ± 22.9	136.7 ± 26.1	0.7873 [2]	0.4768 [2]	0.6697 [2]
Diastolic BP (mmHg)	81.2 ± 14.2	80.6 ± 14.6	80.9 ± 14.1	0.7393 [2]	0.8628 [2]	0.8757 [2]
Number of patients with BP ≤ 140/80 mmHg	62	61	46	0.8808 [1]	0.1270 [1]	0.1640 [1]
Mean HbA1c, %	12.18 ± 2.93	11.08 ± 2.86	10.57 ± 2.80	0.0016 [2]	0.1280 [2]	<0.0001 [2]
Number of patients with HbA1c ≤ 7, %	6	16	19	0.0241 [1]	0.5721 [1]	0.0054 [1]
Mean total cholesterol (mmol/l)	4.64 ± 1.31	4.40 ± 1.09	4.32 ± 1.08	0.1185 [2]	0.5756 [2]	0.0401 [2]
Mean triglyceride (mmol/l)	2.16 ± 1.38	1.88 ± 1.12	2.02 ± 1.17	0.0773 [2]	0.3557 [2]	0.3707 [2]
Mean HDL cholesterol (mmol/l)	1.18 ± 0.43	1.23 ± 0.37	1.29 ± 0.40	0.3231 [2]	0.1670 [2]	0.0252 [2]
Mean LDL cholesterol (mmol/l)	2.41 ± 1.03	2.13 ± 0.87	2.34 ± 1.14	0.0403 [2]	0.1209 [2]	0.6290 [2]
Number of patients with:						
Total cholesterol < 4.5 mmol/l	65	79	74	0.0882 [1]	0.8018 [1]	0.1503 [1]
Triglyceride < 1.7 mmol/l	52	67	58	0.0575 [1]	0.3742 [1]	0.3178 [1]
Mean waist circumference (cm)	108.91 ± 15.73	108.0 ± 17.06	107.8 ± 14.9	0.6563 [2]	0.9050 [2]	0.5497 [2]
Mean BMI(kg/m^2)						
Males	28.93 ± 5.85	28.64 ± 6.15	28.17 ± 5.82	0.8411 [2]	0.7533 [2]	0.5984 [2]
Females	35.11 ± 7.36	35.39 ± 7.50	35.15 ± 9.42	0.7896 [2]	0.8498 [2]	0.9688 [2]
Number of patients with WTHR < 0.5	4	6	5	0.4639 [1]	0.7785 [1]	0.6552 [1]
Number of patients with:						
Glycosuria	74	55	64	0.0297 [1]	0.0849 [1]	0.6875 [1]

*[1] Chi-square; [2] Student's t-test.

clinician. This will ensure that the clinician makes an informed decision with regard to lifestyle and medication modification. Future studies will evaluate the impact of this in the clinic.

References

1. International Diabetes Federation diabetes atlas. IDF [homepage on the internet]. 2014. Available from http://www.idf.org/diabetesatlas.
2. Amod A, Riback W, Schoeman HS. Diabetes guidelines and clinical practice: is there a gap? The South African cohort of the international diabetes management practices study. J Endocrinol Metab Diabetes S Afr. 2012;17(2):85–90.
3. Pillay S, Aldous C, Mahomed F. Diabetic patients served at a regional level hospital: what is their clinical picture? J Endocrinol Metab Diabetes S Afr. 2015;20(1):60–6.
4. American Diabetes Association. Implications of United Kingdom prospective diabetes study. Diabetes Care. 2002;26 Supp 1:S28–32.
5. Shlomowitz A, Feher MD. Anxiety associated with self-monitoring of capillary blood glucose. S Afr J Diabetes Vasc Dis. 2014;11(4): 163–6
6. Patrick AW, Gill GV, MacFarlane IA, Cullen A, Power E, Wallymahmed M. Home glucose monitoring in type 2 diabetes: is it a waste of time? Diabetic Med. 1994;11(1):62–5.
7. Guerci B, Drouin P, Grangé V, Bougnères P, Fontaine P, Kerlan V, et al. Self-monitoring of blood glucose significantly improves metabolic control in patients with type 2 diabetes mellitus: the Auto-Surveillance Intervention Active (ASIA) study. Diabetes metab. 2003;29(6):587–94. doi:10.1016/S1262-3636(07)70073-3.
8. McAndrew L, Schneider SH, Burns E, Leventhal H. Does patient blood glucose monitoring improve diabetes control?: A systematic review of the literature. Diabetes Educ. 2007;33(6):991–1010. doi:10.1177/0145721707309807.
9. Farmer A, Wade A, Goyder E, et al. Impact of self-monitoring of blood glucose in the management of patients with non-insulin treated diabetes: open parallel group randomized trail. BMJ. 2007;335(7611):132–132. doi:10.1136/bmj.39247.447431.BE.
10. O'Kane MJ, Bunting B, Copeland M, Coates VE, et al. Efficacy of self-monitoring of blood glucose in patients with newly diagnosed type 2 diabetes (ESMON study): randomized controlled trial. BMJ. 2008 Apr 17;336(7654):1174–7. doi:10.1136/bmj.39534.571644.Epub2008.
11. Pillay S, Lutge E, Aldous C. The burden of diabetes mellitus in KwaZulu-Natal's public sector-a five-year perspective. S Afr Med J. 2016;106(4): 384–8. doi:10.7196/samj.2016.v10614.9920.
12. Kannel WB, McGee DL. Diabetes and cardiovascular disease. JMJA. 1979;241:2035–8.
13. Yusuf S, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364:937–52.

14. Amod A, Ascott-Evans BH, Berg GI, Blom DJ, Brown SL, Carrihill MM, et al. The 2012 SEMDSA guidelines for management of type 2 diabetes. J Endocrinol Metab Diabetes S Afr. 2012;17(2):S56–8.
15. Ford ES, Williamson DF, Liu S. Weight change and diabetes incidence: findings from a national cohort of US adults. Am J Epidemiol. 1997;146:214–22.
16. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9945):766–81. doi:10.1016/S0140-6736(14)60460-8.
17. Motala AA, Esterhuizen T, Pirie FJ, Omar MAK. The prevalence of metabolic syndrome and determination of the optimal waist circumference cutoff points in a rural South African community. Diabetes Care. 2011;34(4):1032–7.
18. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. Nutrition Research Reviews. 2010;23(02):247–69.
19. Pillay S, Aldous C, Mahomed F. Improvement noted after a multifaceted approach to diabetes mellitus management. J Endocrinol Metab Diabetes S Afr. 2016;21(1):8–12. doi:10.1080/16089677.2015.1129704.
20. Gordon T, Castelli WP, Hjortland MC, Kannel WB, Dawber TR. High density lipoprotein as a protective factor against coronary heart disease. Am J Med. 1977;62:707–14.
21. Gordon DJ, Probstfield JL, Garrison RJ, et al. High-density lipoprotein cholesterol and cardiovascular disease. Four prospective American studies. Circulation. 1989;79:8–15.

Received: 07-02-2016 Accepted: 02-06-2016