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Estimated glucose disposal rate (eGDR) in rural Bangladeshi population and its correlation with cardiometabolic risks

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Abstract

Background and objectives: For decades type 2 diabetes mellitus (T2DM) and insulin resistance (IR) are increasingly gaining importance as an underlying mechanism for increased risk of cardiovascular diseases (CVD). IR is related to various cardiometabolic adverse effects.

Hyperinsulinemic-euglycemic clamp technique, the gold standard method for measuring IR, is an invasive and complex procedure. Estimation of glucose disposal rate (eGDR) is an easy alternative tool for measuring IR. There is no known study on eGDR level in Bangladeshi native population. Therefore, this study was undertaken to determine the eGDR values in a healthy working rural Bangladeshi population.

Materials and methods: Six villages were selected purposively as the study sites. All healthy working people aged ≥20 years in selected rural community were considered eligible. Those who consented to participate in the study were enrolled. Investigations included a) interviewing for social and clinical history, b) anthropometry and measurement of blood pressure and d) estimation of HbA1c and biochemical indices. The eGDR (mg/kg/min) was calculated using formula: eGDR = 21.158 − (0.09 * WC) − (3.407 * HT) − (0.551 * HbA1c); where WC = waist circumference in cm, HT = hypertension (yes = 1/no = 0), and HbA1c = HbA1c (%).

Results: A total of 93 (m/w = 29/64) participants were enrolled in the study. The prevalence rates of hypertension, diabetes and metabolic syndrome (MSyn) were 34%, 31.1% and 16.1%, respectively. The mean eGDR value was 9.9 (±0.149; 95% CI: 9.62–10.2) mg/kg/min. Most of the values of biophysical characteristics were normal. The comparison between participants with and without MSyn showed that the former had significantly lower eGDR (9.05±1.24 vs.10.10±1.37, p<0.01). Inverse correlations of eGDR with the obesity, glycemia and lipidemia (weight, waist, FBG, T-chol, and TG) were significant. Declining eGDR were significant with rising WHR, WHtR, TG/HDLR and T-chol/HDLR (for all, p<0.05).

Conclusions: The study revealed the level of eGDR in a healthy working people of a rural community of Bangladesh. Moreover, eGDR was found to decrease significantly with the increasing cardiometabolic risks. The study revealed a higher prevalence of hypertension, diabetes and metabolic syndrome in apparently healthy working people highlighting susceptibility of Bangladeshi natives to non-communicable diseases.

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Introduction

A substantial number of the recent studies emphasize the importance of estimated glucose disposal rate (eGDR) for predicting cardio-cerebrovascular events, which indirectly measure the insulin resistance and overall metabolic dysfunctions [1-3]. It was reported that an eGDR level less than 8.77 mg/kg/min showed 100%

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sensitivity and 85.2% specificity for the diagnosis of metabolic syndrome [4,5]. Additionally, lower eGDR is related to micro-vascular complications like retinopathy, nephropathy and neuropathy [6]. Apart from micro- and macro- vascular complications, events like acute coronary syndrome are related to abnormal eGDR [7]. Also, individuals with type 1 diabetes mellitus (T1DM) and low eGDR have altered cholesterol and triglycerides [8]. These studies substantiate the significance of eGDR as an easy alternative tool for determining insulin resistance and to predict metabolic dysfunctions in a large population. To date, no study has yet been done on eGDR on Bangladeshi population. Therefore, this study was designed to measure the eGDR values in an apparently healthy working people of rural community of Bangladesh. Some other known metabolic variables related to metabolic syndrome (obesity, blood pressure, blood glucose, lipids) were also investigated to determine their associations with eGDR.

Materials and methods

The study was approved by Institutional Ethical Review Committee and conducted over 4 months period from September 2022 to December 2022.

Geographical site and participants: Six villages inhabited by mostly lower and middle class families were purposively selected. Occupationally these people were engaged in pottery, pottery-art and clay-modeling; some had mixed occupations like agriculture, teaching, and small-scale business. The study area is situated at a distance of about 38 km north of Dhaka City.

The village social leaders and school teachers were discussed about the objectives and procedural details of the expected investigation. After obtaining the consent, the medical students of Ibrahim Medical College (Batch-19) prepared the participants' list by house to house visit. The local volunteers helped them to access the participants' house. A pretested questionnaire detailing social and clinical history was filled up following face to face interview. Each participant was requested to attend the local Gonoshasthya Kendra Hospital (GKH) in the next morning with overnight fast for further investigations.

Investigations: At GKH, height, weight, waist-girth, and hip-girth were measured. Blood pressure was measured after rest for 10 minutes. Maintaining aseptic measure, 5ml venous blood was taken. HbA1c was measured from a drop of whole blood by the hemoglobinA1c analyzer (Glycohemoglobin analyzer). Blood sample was centrifuged. Serum was separated and kept in 2 aliquots, frozen and transported to IMC Biochemistry Laboratory for estimation of fasting blood glucose (FBG), total cholesterol (T-chol), triglycerides (TG), high density lipid (HDL), low density lipid (LDL), serum glutamate pyruvate transaminase (SGPT) and creatinine.

The eGDR (mg/kg/min) was calculated using formula: eGDR = 21.158 − (0.09 * WC) − (3.407 * HT) − (0.551 * HbA1c); where WC = waist circumference in cm, HT = hypertension (yes = 1/no = 0), and HbA1c = HbA1c (%) [1].

Participants diagnosed as having DM, HTN and MSyn for the first time were registered at non-communicable disease (NCD) corner of GKH for management and follow-up.

Statistical analysis: The prevalence rates were shown in percentages. The bio-physical characteristics and cardio-metabolic risk variables were expressed in mean (±SD) and 95% confidence interval (CI). Comparison between groups (men vs. women) and Msyn (with vs. without) were tested by independent *t-test*). The rising or declining trend of mean values of risk variables with quartiles of eGDR were estimated by ANOVA. Correlations of eGDR with different biophysical variables were assessed by Pearson's Correlation coefficient (***r***) adjusted for sex only and also for age and sex. Level of significance was accepted at less 0.05. SPSS was used for all analyses.

Results

A total of 93 (m/w = 29/64) participants volunteered the study. Table-1 illustrates the bio-physical characteristics and eGDR values of the participants as mean and 95% CI. The mean eGDR was 9.9±0.15 (95% CI: 9.62-10.2) mg/kg/min. Most of the other values were found to be normal.

The comparisons between men and women (Table-2) showed that men were significantly older (age,

p=0.002), obese (BMI, p=0.006) and hyperglycemic (FBG, p=0.009; HbA1c, p<0.001) than the female participants. Men compared to women had significantly (p=0.009) lower eGDR (men: 9.3713 vs. 10.1999).

Table-1: *Characteristics of the participants (n=93)*

Variable	Mean	SEM	95% CI
Age (y)	49.9	1.42	47.08 – 52.7
BMI (kg/m^2)	23.4	0.376	22.7 – 24.2
WHR	0.958	0.014	0.921 – 0.988
WHtR	0.555	0.007	0.541 – 0.569
SBP (mmHg)	126	1.83	123 – 130.3
DBP (mmHg)	84.0	1.37	81.3 – 86.7
FBG (mmol /L)	6.8	0.206	6.46 – 7.3
T-chol (mg/dl)	126	3.68	119 – 133
TG (mg/dl)	138	7.81	122 – 153
HDL (mg/dl)	43.30	0.54	42.2 – 44.3
LDL (mg/dl)	56.4	3.02	50.5 – 62.4
Creatinine (mg/dl)	0.933	0.055	0.823 – 1.04
SGPT (mg/dl)	22.33	1.798	18.75 – 25.9
HBA1c (%)	6.58	0.164	6.26 – 6.9
eGDR (mg/kg/min)	9.9	0.149	9.62 – 10.2

Note: SEM – standard error of mean, CI – confidence interval; BMI – body mass index (weight in kg/height in met sq), T-chol – total-cholesterol, DBP – diastolic blood pressure, eGDR– estimated glucose disposal road, FBG – fasting blood glucose, HBA1c – hemoglobin A1c, HDL –high-density lipoproteins, LDL – low density lipoproteins, SBP – systolic blood pressure, SGPT – serum glutamate pyruvate transaminase (ALT), TG – triglycerides, WHR – waist-to-hip ratio, WHtR – Waist-to-height ratio.

Table-2: *Comparison of characteristics between men and women (m/w = 29/64)*

Characteristics	Men		Women		*p*
	Mean	SD	Mean	SD	
Age (y)	56.34	10.765	47.00	14.031	*.002*
BMI (kg/m^2)	24.9849	2.71252	22.7712	3.80110	*.006*
WHR	.9395	.10037	.9683	.15583	*.369*
WHtR	.5593	.06450	.5536	.06970	*.713*
SBP (mmHg)	128.45	16.856	125.86	18.182	*.517*
DBP (mmHg)	87.07	10.980	82.66	14.029	*.138*
FBG (mmol /L)	7.667	2.6635	6.517	1.4968	*.009*
T-chol (mg/dl)	129.59	43.459	125.33	31.579	*.595*
TG (mg/dl)	156.52	106.210	130.25	55.421	*.120*
HDL (mg/dl)	44.14	5.343	42.92	5.214	*.304*
LDL (mg/dl)	53.10	31.467	58.03	28.116	*.453*
Creat (mg/dl)	1.0143	.36789	.8968	.58253	*.329*
SGPT (mg/dl)	26.1739	16.14889	20.0769	12.41261	*.100*
HBA1c (%)	7.4203	2.12362	6.2131	1.10009	*.000*
eGDR (mg/kg/min)	9.3713	1.54177	10.1999	1.26066	*.009*

*Note: SD – standard deviation, p – level of significance after 't- test'; BMI – body mass index (*kg/m^2*), T-chol – total-cholesterol, DBP – diastolic blood pressure, eGDR– estimated glucose disposal road, FBG – fasting blood glucose, HBA1c – hemoglobin A1c, HDL –high-density lipoproteins, LDL – low density lipoproteins, SBP – systolic blood pressure, SGPT – serum glutamate pyruvate transaminase (ALT), TG – triglycerides, WHR – waist-to-hip ratio, WHtR – Waist-to-height ratio.*

The prevalence of systolic hypertension, diabetes and metabolic syndrome were 34.1%, 31.1% and 16.1% respectively as shown in (Table-3). Men and women did not show any significant differences.

Comparison between participants with and without MSyn (Table-4) showed that the cardio-metabolic risks were significantly higher among those with than those without MSyn. Thus, BMI, SBP, TG, were all significantly higher among the MSyn group (for all p <0.05). As expected, the mean (±SD) values of

Table-3: *Prevalence of hypertension, diabetes and metabolic syndrome by gender*

Disease	n	%	chi-sq: p (men vs. women)
Systolic Hypertension (sHTN)			
Men	12	13.2	
women	19	20.9	1.39; *0.338*
Total	31	34.1	
Diastolic hypertension (dHTN)			
Men	17	18.7	2.47; *0.172*
women	27	29.7	
Total	44	48.4	
Type-2 diabetes mellitus (T2DM)			
Men	13	14.4	3.75; *0.087*
women	15	16.7	
Total	28	31.1	
Metabolic syndrome (MSyn)			
Men	7	7.5	1.99; *0.223*
women	8	8.6	
Total	15	16.1	

Table-4: *Comparison of characteristics between participants with (n=15) and without (n=78) metabolic syndrome (MSyn)*

Characteristics	Participants with MSyn (n = 15)		Participants without MSyn (n = 78)		*p*
	Mean	±SD	Mean	±SD	
Age (y)	55.13	9.34	48.9	14.2	*.109*
BMI (kg/m^2)	26.2	2.14	22.9	3.63	*.001*
WHR	0.930	0.088	0.964	0.148	*.397*
WHtR	0.580	0.060	0.550	0.068	*.121*
SBP (mmHg)	136.0	12.42	124.8	18.09	*.025*
DBP (mmHg)	89.3	14.37	83.0	12.87	*.091*
FBG (mmol /L)	7.47	1.71	6.7	2.03	*.206*
Chol (mg/dl)	137.0	45.1	124.6	33.3	*.217*
TG (mg/dl)	213.7	91.02	123.9	63.0	*.000*
HDL (mg/dl)	45.9	5.81	42.7	5.02	*.033*
LDL (mg/dl)	48.9	29.10	57.9	29.08	*.275*
Creatinine (mg/dl)	1.05	0.487	0.911	0.533	*.369*
SGPT (mg/dl)	28.21	14.38	20.62	13.69	*.076*
HBA1c (%)	7.20	1.44	6.47	1.59	*.104*
eGDR (mg/kg/min)	9.05	1.24	10.10	1.37	*.008*

Note: p value by 't- test'; BMI– body mass index , T-chol – total-cholesterol, DBP – diastolic blood pressure, eGDR– estimated glucose disposal road, FBG – fasting blood glucose, HBA1c – hemoglobin A1c, HDL –high-density lipoproteins, LDL – low density lipoproteins, SBP – systolic blood pressure, SGPT – serum glutamate pyruvate transaminase, TG – triglycerides, WHR – waist-to-hip ratio, WHtR – Waist-to-height ratio.

eGDR was significantly lower among those who had MSyn compared to those who had no MSyn (eGDR, mg/kg/min: 9.05±1.24 vs.10.10±1.37, p<0.01).

Correlation matrices controlling for sex and controlling for age and sex are shown in Table-5 and 6 respectively.

Table-5: *Correlations ('r') of eGDR with bio-physical characteristics controlling for sex*

		eGDR	AGE	HT	WT	WST	FBG	CHOL	TG	HDL	LDL
eGDR	*'r'*	1.000	.148	-.476*	-.688*	-.697*	-.553*	-.267*	-.513*	.053	-.055
	p	.	.176	.000	.000	.000	.000	.014	.000	.629	.615
AGE	*'r'*		1.000	-.012	-.135	-.194	-.027	.041	.000	.020	.015
	p		.	.917	.217	.075	.803	.707	.998	.857	.893
HT	*'r'*			1.000	.739	.408	.129	.217	.243	-.012	.120
	p			.	.000	.000	.241	.046	.025	.910	.275
WT	*'r'*				1.000	.708	.198	.320	.307	.018	.182
	p				.	.000	.070	.003	.004	.869	.095
WST	*'r'*					1.000	.185	.065	.258	.013	-.086
	p					.	.090	.555	.017	.904	.433
FBG	*'r'*						1.000	.182	.419	.030	.010
	p						.	.096	.000	.789	.931
CHOL	*'r'*							1.000	.464	.336	.848
	p							.	.000	.002	.000
TG	*'r'*								1.000	.380	.018
	p								.	.000	.871
HDL	*'r'*									1.000	.027
	p									.	.806

Note: 'r' – correlation coefficient, p – two tailed significance: eGDR correlated significantly with height (HT, p<0.001), weight (WT, p<0.001), waist (WST, p<0.001), fasting blood glucose (FBG, p<0.001), T-cholesterol (T-chol, p = 0.014) and triglycerides (TG p<0.001) but not with HDL and low LDL as depicted in the first row.

Table-6: *Correlations ('r') of eGDR with cardiometabolic risks controlling for age and sex*

		BMI	WHR	WHtR	eGDR	SBP	DBP	FBG	TG	CHOL
BMI	*'r'*	1.000	-.005	.640	-.475*	.047	-.059	.142	.182	.226
	p	.	.966	.000	.000	.671	.596	.199	.098	.039
WHR	*'r'*		1.000	.439	.041	.038	-.033	-.122	-.091	-.181
	p		.	.000	.711	.731	.765	.270	.411	.100
WHtR	*'r'*			1.000	-.434*	.050	-.104	.111	.133	-.063
	p			.	.000	.654	.344	.317	.229	.569
eGDR	*'r'*				1.000	.058	.086	-.555*	-.519*	-.276*
	p				.	.599	.434	.000	.000	.011
SBP	*'r'*					1.000	.804	-.132	.002	-.099
	p					.	.000	.233	.989	.369
DBP	*'r'*						1.000	-.157	-.062	-.079
	p						.	.155	.573	.477
FBG	*'r'*							1.000	.419	.183
	p							.	.000	.096
TG	*'r'*								1.000	.464
	p								.	.000

Note: 'r' – correlation coefficient, p – two tailed significance: eGDR correlated significantly with BMI (p<0.001), WHtR (p<0.001), FBG (p<0.001), TG (p<0.001) and T-chol (p = 0.011); whereas, others did not show any correlation (HDL and LDL not shown in the table).

Correlations of eGDR with the biophysical characteristic - height, weight, waist, FBG, T-chol, and TG were found negatively significant (first row, Table-5). Thus, the findings showed inverse associations – indicating that higher the obesity, glycemia, lipidemia lower the eGDR. These significant inverse correlations of eGDR with cardiometabolic risks factors namely BMI, WHtR in column 4, and FBG, TG, T-chol in row 4 of Table-6 were maintained even when adjusted for age and sex.

ANOVA was employed to test whether decreasing quartile of eGDR (Q4→Q3→Q2→Q1) with increasing level of bio-physical risk variables were significant (Figure-1 and 2). Inverse associations were significant with central obesity (WST , $p<0.001$) and TG ($p<0.001$) though weight (wt), systolic blood pressure (sbp) and T-chol were found not significant (Figure-1). Likewise, cardiometabolic risks were found to increase significantly with declining eGDR (Figure-2). Inverse trends of declining eGDR were significant with the rise of WHR, WHtR, TG/HDLR and T-chol/HDLR (for all $p<0.05$).

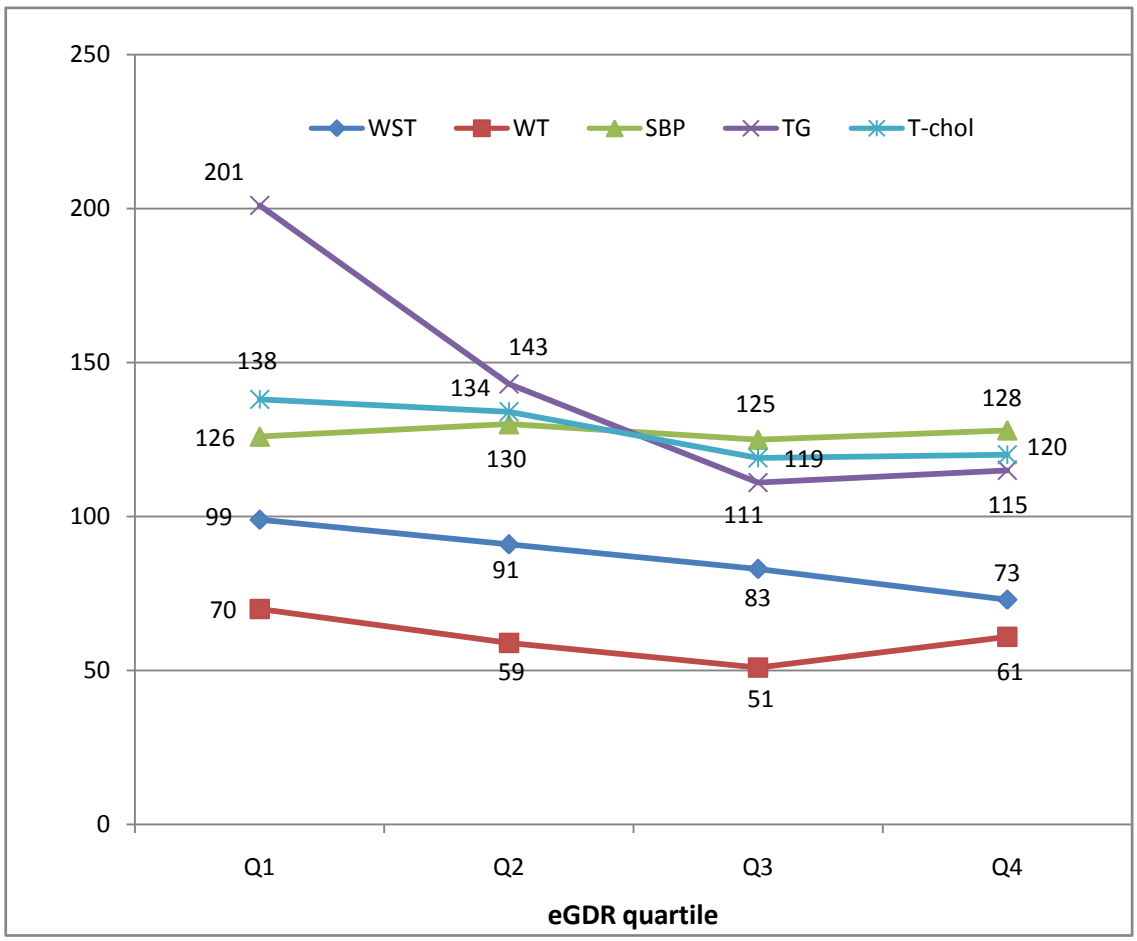

Figure-1: *ANOVA determined the mean values of WST (cm), WT (kg), SBP (mm), TG (mg/dl), T-chol (mg/dl) according to quartiles (Q1:≤8.8, Q2:8.9 – 9.9, Q3:9.10 – 10.7, Q4: ≥10.8) of eGDR*

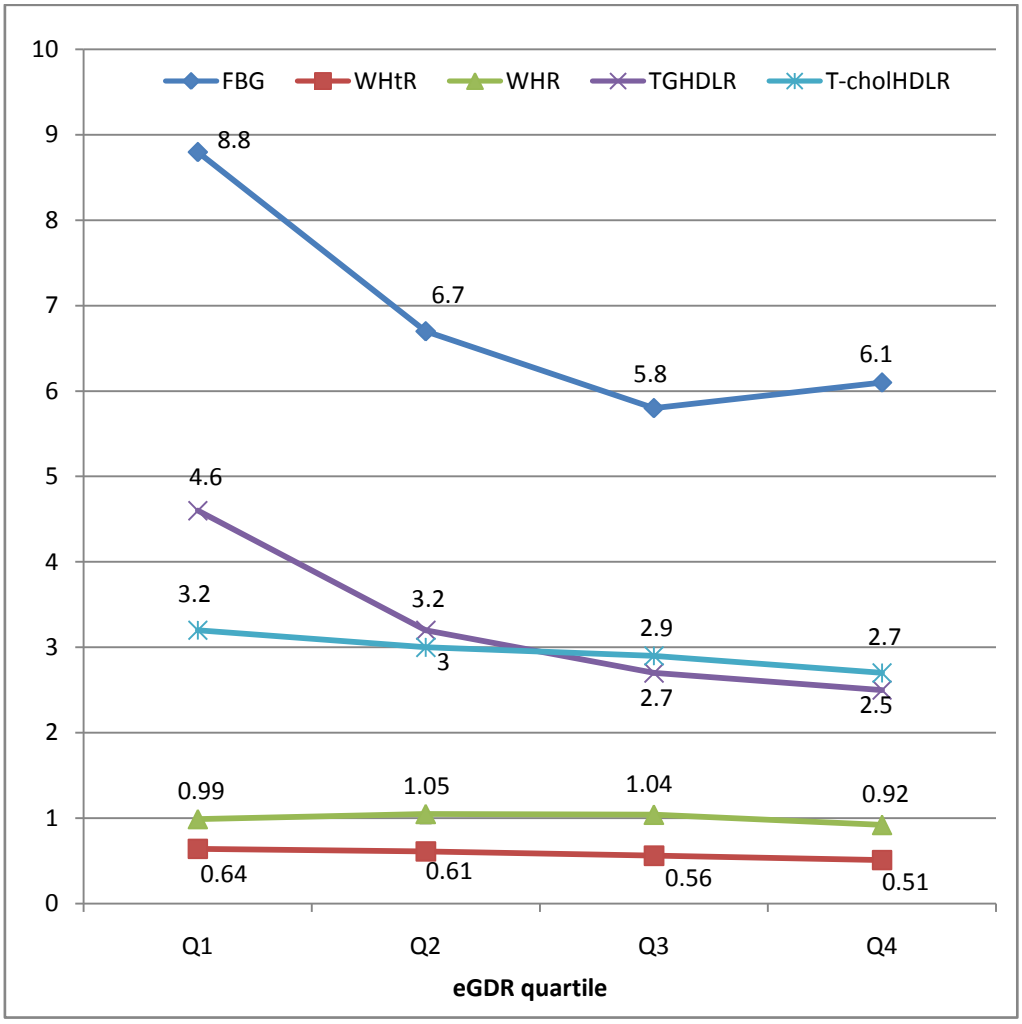

Figure-2: *ANOVA estimated the mean values of WHR, WHtR, FBG (mmol/L), TG/HDL Ratio, T-chol/HDL Ratio according to quartiles (Q1:≤8.8, Q2:8.9 – 9.9, Q3:9.10 – 10.7, Q4: ≥10.8) of eGDR*

Discussions

As mentioned, there was no published report to date on eGDR on Bangladeshi population. There are many studies which investigated the status of eGDR on the patients suffering from diabetes (type1 & type2) with macro- [1-5,7-10] and micro-angiopathy [6]. Thus, the present study was unique, as it was conducted on working apparently healthy rural people. It is difficult to compare this study findings with other studies. Very important outcome of this study is that we could determine the level of eGDR in healthy community population (95%CI, 9.62 – 10.2 mg/kg/min). This range of eGDR value may be used as reference one until we get a value level based on well-designed study with larger number of samples. Other outcomes are also important like the prevalence of hypertension (34.1%), T2DM (31.1%) and MSyn (16.1%) in a rural community of Bangladesh. The prevalence of hypertension (34.1%) is consistent, though higher than that reported by Kibria et al [11]. Prevalence rates for T2DM and MSyn are consistent with Talukder et al [12] and Chowdhury et al [13], respectively.

One striking observation was that the HDL level was significantly higher among the MSyn group than the non-MSyn group. This was a contradiction to the overall cardiometabolic standards, remained unexplained and unclear. Possibly, the guideline as proposed by National Cholesterol Education Program III Guidelines is not applicable on Bangladeshi people with MSyn. Bangladesh including south Asian population needs own guideline for MSyn as we proposed earlier in 2008 [14].

Conclusion

The study revealed the range of eGDR values in apparently healthy rural population of Bangladesh. The significance of correlations of eGDR with cardiometabolic risks (obesity, hypertension, hyperglycemia, and hyperlipidemia) was also projected. In addition, the study revealed a higher prevalence of hypertension, diabetes and metabolic syndrome in apparently healthy rural working people highlighting susceptibility of Bangladeshi natives to NCDs. These findings demand health screening at regular interval. The findings are baseline and suitable for an excellent cohort to assess the natural course of different eGDR-quartiles in a Bangladeshi population in future.

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Competing interest

The authors declare no conflict of interest.

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