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Association Between Glycemic Load and Diabetes Mellitus Among Women: Case of Amagoro Division in Western Kenya

Rebecca. A. Ebere[1], Violet. N. Kimani[2], Jasper. K. Imungi[3]
Lambert. O. Nyabola[4]
[1]*School of Public Health, University of Nairobi*
[2]*School of Public Health, University of Nairobi*
[3]*Department of Food Science, Technology and Nutrition, University of Nairobi*
[4]*School of Public Health, University of Nairobi*
Corresponding Author: Rebecca. A. Ebere[1]

Abstract: *Glycemic load (GL) has been found to be a stronger measure for glycemic response to carbohydrate-rich foods. This is because it accounts for both the quality and quantity of carbohydrates consumed. This study therefore investigated the association between the total glycemic load from Kenya's most popular staple food "ugali", with diabetes mellitus type 2 (DM2). The study was cross-sectional involving 260 women aged 18 – 90 years drawn from households located in Amagoro division of Western Province of Kenya. Households were chosen by cluster and stratified sampling. Data on demography, socio-economy and diabetes status were collected by interviews using pre-tested questionnaires. Blood sugar levels were measured using a glucometer and levels ≥7.8 mmol/L underwent a confirmatory test using fasting blood sugar. Anthropometric measurements were taken following standard protocols with some modifications. Body mass index was obtained by dividing weight (kg) by height (m^2) and classified as underweight (<18.5); normal weight (18.5-24.9); overweight (25.0-29.9) and obesity (≥30). Waist circumference > 88 cm indicated abdominal obesity. Waist-hip-ratio >0.80 was considered abnormal. The total GL was calculated by adding glycemic load of individual ugali-based meals. The odds ratio showed that those consuming glycemic load ≥ 840 per week were 1.25 times more likely to have DM2 as opposed to those consuming GL less that 840 per week although this finding was not statistically significant (OR= 1.25, 95% CI - OR 0.48-3.27, p=0.646). After controlling for confounding variables, no significant association was found between GL and DM2 although those consuming more >840 were 1.36 times more likely to suffer from DM2 as opposed to those on moderate load. Physical activity and alcohol consumption were the independent risk factors for DM2 in this population (p<0.05).*

Key words: *glycemic load, diabetes mellitus type-2, women, Western Kenya*

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I. Introduction

As a result of rising cases of chronic diseases such as diabetes mellitus, there is a growing interest globally on the effect that foods rich in carbohydrates have on blood sugar responses. These responses can be measured in terms of glycemic indices (GI) and glycemic loads (GL).

Irrespective of the GI of a foodstuff, the blood sugar response to a carbohydrate-rich meal depends on the portion size. Glycemic Load (GL) has therefore been used as an alternative measure for blood sugar response. The GL takes account of both the quality expressed in terms of GI and the quantity of the meal consumed. The GL is calculated by multiplying the dietary carbohydrate content with the GI of the food and dividing by 100. The higher the GL, the greater is the rise in blood glucose. The GL of foods has thus been categorized as low (GL=1-10,) medium (GL=11-19) and high (GL≥20) (Foster-Powell, Holt & Brand-Miller, 2002).

Only limited information is available on glycemic responses of African traditional foods (Omoregie & Osagie, 2008). *Ugali* as it is popularly known in Kenya is a thick porridge which is mainly prepared from maize (*Zea mays* L.) flour and boiling water (Wanjala et al., 2016). It is served as the main dish usually for lunch or supper and is consumed alongside a side dish (relish) composed of either vegetables, fish, legumes, meats or mixtures thereof (Onyango, 2014, Wanjala et al., 2016). *Ugali* may also be prepared from flours of either cassava (*Manihot esculenta* Crantz L.), finger millet (*Eleusine coracana* (L.) Gaertn), sorghum (*Sorghum bicolor* (L.) Moench) or combinations thereof. The choice depends on the preference, availability and cost of the raw materials as well as the predominant crop in the locality (Wanjala et al., 2016). The stiff porridge is also widely consumed in other parts of Africa including, Tanzania (Ruhembe, Nyaruhucha & Mosha, 2014), Malawi

(Mlotha et al., 2016), Cote d'Ivore (Kouame et al., 2015), Botswana (Mahgoub, Sabone & Jackson, 2013), Nigeria (Omoregie and Osagie) and South Africa (Mbhenyane et al., 2001).

In Amagoro Division of Western Kenya, the commonly consumed stiff porridge is prepared from flours of whole maize or cassava and sorghum mix. Although dietary intervention has been advocated for preventing and managing diabetes (Otieno, Kariuki & Ng'ang'a, 2003, Ruhembe, Nyaruhucha & Mosha, 2014, Wanjala et al., 2016), the direct role of the GL of foods in the development of diabetes especially in populations that subsist on high carbohydrate diets remain obscure (Villegas et al., 2007).

Whole-milled maize, sorghum and finger millet have been recommended for making *ugali* for people with DM2 in Western Kenya (Wanjala et al., 2016) despite lack of data on their associated glycemic response. This study therefore investigated the association between glycemic responses of some *ugali*-based meals consumed in Busia County of Kenya and it is the first study conducted on such meals from the region. The knowledge generated would be important in evaluating the potential of particular *ugali* meals to pose risk of diabetes and thereby hinder or help in the management of DM2 both locally and in other parts of Africa that subsist on a similar diet.

II. Study Design and Methodology

2.1 Study Design

This was cross-sectional study and it was conducted among women aged 18 – 90 years. The study used a structured questionnaire to collect information through self-reporting. The interviews were conducted at the participants' home.

2.2 Study Site

Amagoro division is located in Teso North District of Busia County in Western Kenya.

2.3 Sample size determination

The sample size for the survey was calculated using the formula adopted from Fox, Hunn and Mathers, 2009 namely: $N= P (100\%-P)/ (SE)^2$. N= the desired sample size; P= Proportion of carbohydrates in the diet (80%). SE= the confidence interval of 5% divided by 1.96. In this case the SE= 2.55 and therefore N=246. Allowing 10% attrition, a total of 270 households participated in the study and 260 questionnaires proceeded to analysis having been duly completed.

2.4 Ethical Considerations

Kenyatta National Hospital and University of Nairobi Ethics, Research and Standards Committee reviewed and approved this study. Participants gave an informed consent and for those below 18 years, consent was sought from the guardian/parent.

2.5 Sampling Procedure

From the nine locations in Amagoro division, three locations were sampled for this study as shown in Table 1.

Table 1: Distribution of sample in various locations

Location	Okuleu[1]	Kokare[1]	Amoni[3]	Osajai[4]	Kocholia[2]	Kamolo[3]	Kamuriai[1]	Amarogo[2]	Akadetewai[2]	**Total**
Households	860	823	1525	1125	1324	1589	273	1753	3206	12478
Sub-locations	2	2	2	2	3	3	2	3	2	21
Sample size				68		96		106		270

[1]household below 1000 were eliminated.
[2]located along Malaba-Uganda highway with Amagoro in the middle and therefore sampled.
[3]located in the interior south of Amagoro, Kamolo had the most households and therefore sampled.
[4]located to the interior north of amagoro

The sample size of 270 HHs was then proportionately distributed among the three locations. The sample size per location was then proportionately distributed among the sub-locations in that specific location.
For the household surveys, interviews were conducted to obtain the information on socio-demographic and clinical risk factors as well as physical activity and dietary intake. Measurements were then taken for blood pressure using a blood pressure monitor (AutoTensio SPG 420, France), random blood sugar using a glucometer (*On call* plus, USA) and anthropometric measurements were taken and body mass index computed by dividing the weight (kg) by height (m) squared.

Data was also collected on participants' age, level of education, household income, family history of diabetes, blood pressure, blood sugar, cigarette smoking, alcohol consumption, physical activity and self-reported diabetes status.

A global physical activity questionnaire developed by the World Health Organization was adopted in this study with some modifications. Vigorous and moderate physical activity were multiplied by 8 and 4 respectively to convert them into metabolic equivalent for task (MET) which were then summed as total physical activity and scored in MET hours per day.

2.6 Data Analysis

The analyses were conducted using SPSS version 20.0. Descriptive statistics were used in analyzing and characterizing the survey participants. The data was presented in frequencies including percentages; and by mean including standard deviation. A chi-square analysis was used to compare blood sugar levels with independent variables. In order to determine associations between DM2 and independent variables, binary logistic regression analyses were performed and multivariate logistic regression analysis was used to determine the magnitude of the independent risk factors. The significance level adopted in these tests was 5% ($p<0.05$).

III. Results and Discussion

3.1 Socio-Economic Characteristics of the Household Survey Participants

About half of the survey participants were below the age of 35 years while the elderly were the least at 6.9%. A majority of those who went to school did not go beyond primary level. In fact, only 17.7% completed primary education. This probably explains the low level of employment and household income, with about 85% earning below KES 5000 per month. These socio-demographic risk factors results are shown in Table 2.

Table 2: Socio-economic characteristics of the household survey participants

Risk factor	Categories	Frequency	Percent
Age	<35	136	52.3
	≥65 years	18	6.9
Education level	Never gone to school	35	13.5
	Primary incomplete	129	49.6
	Primary complete	46	17.7
	Secondary incomplete	19	7.3
	Secondary complete	28	10.8
	Tertiary	3	1.2
Income level (KES)	< 5000	222	85.4
	5000-9999	28	10.8
	≥10000	10	3.8
Family history of diabetes	Present	19	7.3
	Absent	241	92.7

Table adapted from: Ebere, Kimani & Imungi (2017a)

3.2 Behavioral Characteristics of the Participants

The participants were generally very active physically, all above the recommended levels by the World Health Organization. A few smoked cigarettes (3.1%) and less than half the sampled population consumed alcohol. These results are shown in Table 3.

Table 3: Behavioral characteristics of participants

Risk factor	Categories	Frequency	Percent
Physical activity (MET hours/day)	< 25	87	33.5
	25-49	150	57.7
	≥ 50	23	8.8
Cigarette smoking	Smokers	8	3.1
	Non-smokers	252	96.9
Alcohol consumption	Yes	88	33.8
	No	172	66.2

3.3 Clinical Factors

A few participants were underweight (6.9%) or obese (3.1%) while the majority (70%) had a normal body weight. Hypertension was at 22.3% and while 16.9% were suffering from DM2. These results together with glycemic load taken in by participants are shown in Table 4.

Table 4: Clinical characteristics of the participants

Clinical factor	Categories	Frequency	Percent
*Body mass index (kgm^{-2})	Underweight	18	6.9
	Normal weight	182	70
	Overweight	52	20
	Obesity	8	3.1
Blood pressure (mmHg)	Normal	202	77.7
	Hypertensive	58	22.3
Glycemic load (GL)	< 420	121	46.5
	421-840	79	30.4
	>840	60	23.1
Diabetes mellitus (DM2)	Diabetic	44	16.9
	Normal	216	83.1

*Adapted from Ebere, Kimani and Imungi (2017a)

3.4 Glycemic Load of *Ugali* Meals

Ugali was the food of choice because it was the most commonly consumed (Ebere, Kimani & Imungi, 2017b). All the meals fell under high GL category (≥20). The highest was recorded by cassava-sorghum *ugali* consumed with silver fish (41) and lowest was from whole-maize *ugali* consumed with cowpea leaves (22.7). These results are as shown in Table 5.

Table 5: Glycemic load of the test meals

Test meals	Glycemic load
Whole maize *ugali* eaten with beef	35.4
Whole maize *ugali* eaten with silver fish	34.5
Whole maize *ugali* eaten with cowpea leaves	22.7
Cassava-sorghum *ugali* eaten with silver fish	41.0
Cassava-sorghum *ugali* eaten with cowpea leaves	34.6

Adapted from Ebere, Imungi & Kimani VN (2017a) and Ebere, Imungi & Kimani (2017b).

The total glycemic load was categorized into three low, medium and high considering the cut-off values of 10 (representing low GI), this study considered that the participants normal average serving size is thrice the above value of 10, and *ugali* was mostly consumed twice a day (for lunch and supper) and considering seven days of the week then the lower category was therefore computed by multiplying 10 by 3 by 2 by seven to get the weekly load which was 420. The same was considered for the high GL foods (≥20) resulting to a load of ≥840. The figures in between formed the moderate GL values (421-840).

3.5 Glycemic Load in Association with Diabetes Mellitus

The mean weekly glycemic load from *ugali* meals was 593.08±466.98. With regard to diabetes mellitus, the distribution was as shown in Table 6.

Table 6: Distribution of participants by total glycemic load in relation to diabetes status

Glycemic Load	Diabetes Status	
	Diabetic n (%)	Normal n (%)
<420	19 (43.2)	101 (46.8)
421-839	16 (36.4)	63 (29.2)
≥840	9 (20.5)	52 (24.1)

3.6 Determination of Odds Ratio

Univariate logistic regression analysis for diabetes mellitus in relation to total glycemic load from *ugali* meals was conducted. The odds ratio showed that those consuming glycemic load ≥ 840 per week were 1.25 times more likely to have DM2 as opposed to those consuming glycemic load less that 840 per week although this finding was not statistically significant (OR= 1.25, 95% CI for OR 0.48-3.27, p=0.646). After controlling for other variables, this association was lost although those who consumed ≥ 840 per week were 1.25 times higher chance for DM2 as opposed to those consuming 421-839 per week although this finding was also not statistically significant. The glycemic load together with other variables was taken through multivariate logistic regression and the results are shown in Table 7.

Table 7: Multivariate regression results for participants' characteristics in relation to diabetes

Risk factor	**Categorization**	***p*-value**	**OR (95% CI for OR)**
Age (years)	<35 (ref)	-	1
	35-64	0.95	0.97 (0.38-2.47)
	≥65	0.75	0.69 (0.07-6.96)
Education level	No schooling	0.27	2.74 (0.45-16.50)
	Primary education	0.33	1.73 (0.57-5.25)
	≥Secondary education (ref)	-	1
Household income (KES)	< 5000	0. 20	4.49 (0.46-43.65)
	5001-10000	0.3	3.64 (0.32-41.89)
	>10000 (ref)	-	1
Family history	Present	0	0.06 (0.20-0.24)
	Absent (ref)	-	1
Physical activity (MET hrs/day)	<25	0	12.41 (3.00-51.37)
	25-49	0.04	3.30 (1.07-10.18)
	≥50 (ref)	-	1
Cigarette smoking	Smokers	0.26	0.20 (0.01-3.36)
	Non-smokers (ref)	1	1
Alcohol consumption	Drinkers	0.03	2.78 (1.08-7.15)
	Non-drinkers (ref)	-	1
Body mass index (kgm^{-2})	<25 (ref)	-	1
	≥25	0.96	0.97 (0.34-2.76)
Blood pressure (mmHg)	Normal (ref)	-	1
	High	0.31	1.77 (0.59-5.32)
Glycemic load	0-420 (ref)	-	1
	421-839	0.21	0.53 (0.20-1.41)
	≥840	0.61	0.72 (0.21-2.51)

After controlling for the confounding variables this study did not find any association between age, family history of diabetes, cigarette smoking, BMI and glycemic load with diabetes mellitus.

Although not statistically significant, socio-economic status as represented by level of education and household income is an important variable with regards to DM2. As opposed to those who had post primary education, those who never went to school 2.74 times more likely to suffer from DM2. In fact, there were 1.58 times more likely to suffer than those who simply went to primary school. Those who earned less than KES 10,000 per month were more likely to suffer from DM2 as compared to those earning above KES 10, 000 although all participants fall under low income group.

Those with hypertension were 1.77 times more likely to suffer fromDM2 as opposed to those with normal blood pressure. Hypertension has been found to be common in diabetic people and is estimated to affect 20–60% of the patients (ADA, 2002).

3.7 Independent Risk Factors for Diabetes Mellitus

Physical activity and alcohol consumption are the factors significantly associated with DM2 in this population (p<0.05). Those who exercised moderately were 3.3 times more like to suffer from DM2 as opposed who exercised highly (≥ 50 MET hours/day) and those with lower physical activity in this population were 12.41 more likely to suffer from DM2 as opposed to those with higher levels. This is the case in this population despite the fact that all the participants level of physical activity was much higher than that recommended by the World Health Organization (WHO, 2010). This could mean that this population needs higher levels of physical activity to maintain good health and protect against DM2.

Physical activity is known to reduce the risk of DM2 by 35% to 40% (IDF Diabetes Atlas, 2011) approximately 27% of diabetes disease burden has been attributed to physical activity (WHO, 2009). However, the cut-off values may not be applied across the populations. Although WHO recommends level of ≥ 150 minutes of activity of moderate-intensity per week for adults (WHO, 2010) and others recommend walking for ≥ 30 minutes per day (Roberts and Barnard, 2005), this population surpassed all these recommendations and yet physical activity remains an independent risk factor for DM2. This finding concurs with a recent study emphasizing the importance of physical activity on the risk of DM2 (Joseph et al., 2016). Physical activity reduces diabetes risk by controlling body weight, blood pressure and improving body cells' insulin sensitivity (Helmrich et al., 1991; Hu et al., 1999; Folsom, Kushi & Hong, 2000; Colberg et al., 2010).

The other independent risk factor was alcohol consumption. Although earlier studies had found an increased risk of developing DM2 in non drinkers and heavy drinkers, when compared with moderate drinkers (Wei et al., 2000; Ajani et al., 2000; ADA, 2002; Wannamethee et al., 2003), this study found that irrespective of the amount of alcohol, those who consumed alcohol were 2.78 more likely to suffer from DM2 as opposed to those who never consumed alcohol. Nonetheless, the type of alcoholic beverage has also been found to be important. For example, wine was associated with a more significant reduced risk of DM2 compared with beer or spirits (Huang et al., 2017). The women in this study mainly consumed the local brew *busaa* (prepared from cereal grains and malted millet) and *chang'aa* (a locally distilled spirit).

IV. Conclusion

The diet of this population is highly starch-based presented in form of porridge. However, there was no significant association between total glycemic load from *ugali* meals and DM2 (p>0.05). The strongest independent risk factors were alcohol consumption and physical activity.

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