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A comparative study of serum ascorbic acid level in people with and without Type 2 diabetes in Ibadan, Nigeria

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Summary
The serum ascorbic acid status of 46 type 2 diabetic subjects attending the Out-Patient Clinic of the University College Hospital, Ibadan, Oyo State, Nigeria and that of 42 non- diabetic adult subjects who served as control was compared. Interviewer-administered questionnaire was used to collect information on the socio-economic characteristics, and ascorbic-acid intake of the subjects. The body mass index and the serum ascorbic acid status of the subjects were also assessed. The mean age of the diabetics and of the control subjects were 55.9±13.7 and 47.3±11.2 years respectively. A large number (92.3%) of the patients were placed on diet and oral hypoglycaemic drug. The ascorbic acid intake of the diabetic and non-diabetic subjects was not significantly different (P>0.05). Majority (83.4%) of the patients and only 37.2% of the control were either overweight or obese. A high percentage (78.3%) of the patients and 19.7% of the non-diabetic adults serving as control had low serum ascorbic acid level. The mean serum ascorbic acid level of the patients was significantly lower than that of the control (P<0.05). Statistical analysis revealed that duration of illness, body mass index and fasting blood glucose level had significant (P<0.05) and inverse relationship with serum ascorbic acid level of the patients. This study indicates a need to improve the plasma ascorbic acid level of diabetic patients in order to help prevent high level of free radicals which are known to be associated with vascular complications of diabetes.

Keywords: *Serum ascorbic acid level, type 2 diabetic patients, Nigeria.*

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Introduction

An epidemic of diabetes mellitus[DM]is underway. As estimated by the World Health Organization (WHO), 30 million people worldwide had diabetes in 1985. By 2000, the global burden of diabetes had increased to 177 million[1] The latest WHO projections suggests that the number of people with diabetes worldwide will increase to at least 370 million by 2030 [1-2].

Nutritional management is a key component of long-term health and quality of life for people suffering from DM. Vascular disease, constitute the major aspect of the morbidity and mortality in diabetic patients.

Increased oxidative stress has been documented to play an important role in the vascular dysfunction in patients with DM [3-4]. Epidemiological observation indicates that the oxidative stress occurs as a result of an increase in reactive oxygen-derived substances (ROS) production and impairment in the activity of endogenous antioxidant components in diabetic patients [5] Endothelial cell dysfunction caused by hyperglycemia has also been shown to be free radical mediated [4-6].

Ascorbic acid (Vitamin C) is known as an outstanding antioxidant in the human plasma that is capable of scavenging oxygen-derived free radicals that result when the body transforms carbohydrate, fat or protein to energy. It also spares the other endogenous antioxidants from destruction [6,7]. Observations indicate that antioxidant ascorbic acid deficiency could adversely affect capillary integrity [8-9]. Ascorbic acid supplementation has been reported to improve glycaemic control as well as cholesterol and tryglyceride levels in type 2 diabetic patients [9-10].

It has been suggested that adequate serum ascorbate is crucial in reducing common complications of diabetes, which are meditated through free radical damage from autoxidation of glucose and glycosylation of structural proteins [11-14]. It is therefore of clinical and public health importance to evaluate ascorbic acid status of diabetic patients in every locality, in order to have a baseline information that will help to determine the best strategy to help the patients with diabetes maintain adequate ascorbic acid status which has been reported to help prevent common complications of diabetes. This study therefore determines the ascorbic acid level in adults with type 2 diabetes in and in control subjects in Ibadan, Oyo State, Nigeria.

Materials and methods

A cross-sectional study of adult Nigerians diagnosed to have type 2 DM by the endocrinologist attending the University College Hospital (UCH) Ibadan, Oyo State, Nigeria and non-diabetic adult subjects who served as controls, was conducted in September 2005. The controls were age and sex matched with the experimental group. The study was to compare the serum ascorbic acid levels of the subjects. Only patients diagnosed to have type 2 diabetes, and receiving medical care, including diet therapy in UCH Medical Out-Patient Clinic for at least 9 months and gave their consent to participate in the study, were selected alternatively as they sat waiting to consult their doctor. The control consisted of apparently healthy male and female UCH staff-volunteers.

A semi-structured interviewer-administered questionnaire was used to collect information on the socio-economic characteristics and medical history of the subjects and the control. Food frequency questionnaire was also used to assess the fruits and vegetable intake of the subjects and the control. The mean of the diabetic patients' last four consecutive fasting plasma glucose (FPG) levels was obtained from the patients hospital records. The fasting plasma glucose level of the control was determined to exclude diabetes in them

The body mass indices of the subjects (derived by weight (Kg)/height $(m)^2$) were determined and patients were graded into groups based on WHO 1995 recommendation[15]. The serum ascorbate levels of the subjects were determined using Baker and Frank (1968) analytical method [16]. Statistical analysis of range, mean ± standard deviations (SD), frequencies and percentages were determined on the data measured. Chi-square was used to analyze group differences for selected variables, while correlation co-efficient was determined to assess the relationship of the selected variables, with the serum ascorbate of the DM subjects.

Result

As presented in table 1, the subjects consisted of 26 males and 20 females type 2 diabetic patients (Experimental group) and 24 males and 18 female control subjects. The number of male and female subjects in the experimental and control groups was not significantly different ($P>0.05$). The mean age of the patients was 55.8 ± 13.7 years (range 35-72years) and 47.3 ± 11.2 years (range 32-56 years) for the control subjects. The duration of illness of the DM subjects was 4.7 ± 3.8 years (range 1-9 years). A very low percentage (1.4%) of the patients was on diet alone while 98.6% were on diet plus hypoglycemic drugs. The self-reported fruit intake of the subjects and the controls indicate that 62.3% of the subjects and 56.7% of the controls were taking at least an orange or ½ of a grape fruit daily. Only 4.8% and 1.4% of the subjects and the controls respectively were taking vitamin C supplements daily. The mean fasting plasma glucose of the diabetic patients and the controls was 10.3 ± 1.6mmol/L and 4.3± 0.8 mmol/L respectively. All the controls (100.0%) and only about one third (32.5%) of the patients had fasting plasma glucose below 6.7mmol/L. As shown in table 2, majority (83.4%) of the

patients and 37.2% of the control were either overweight or obese (P<0.05). Also the mean serum ascorbate of the patients was significantly lower than that of the control (P<0.05) (see table 2). The duration of illness, level of fruit consumption, intake of supplements of ascorbic acid, fasting plasma glucose level and BMI had significant and inverse relationship with serum ascorbate level of the patients, as shown in figure 1.

Table 1: Characteristics of the subjects and controls

Variables	Subjects(n-46)	Control(n-42)
Sex		
(a) Male	26	24
(a) Female	20	18
Age (years)		
(a) Mean	55.8± 13.7	47.3±11.2
(b) Range	35-72	32-56
Took an orange or ½ of a grapefruit daily.	62.3%	56.7%
Took vitamin C supplements daily	4.8%	1.4%
Mean fasting plasma glucose level(mmol/L)	10.3±0.8	4.3±0.8
≥6.7 mmol/L	67.5%	0.0%
<6.7 mmol/L	32.5%	100.0%

Table 2: The body mass index of the subjects (Who, 1995)

BMI Kg/(m)^2 range	Experimental Group n (%)	Control Group n (%)
<16.5 (Grade III underweight)	0(0.0)	0(0.0)
16.5-16.9 (Grade II underweight)	0(0.0)	0(0.0)
17.0-18.4 (Grade I underweight)	1(2.2)	1(2.4)
18.5-24.9 (Normal range)	7(15.2)	25(59.5)
25.0-29.9 (Grade I obesity) (overweight)	31(67.4)	13(30.9)
30.0-39.9 (Grade II obesity)	6(13.0)	3(7.2)
≥40.0 (Grade III obesity)	1(2.2)	0(0.0)
Total	46(100.0)	42(100.0)

Table 3: The mean serum ascorbate of the subjects

	Experimental group n(%)	Control group n (%)	P-Value
<0.4mg/dl (Low level)	37(80.4)	4(9.5)	<0.05
0.4-1.5mg/dl (Normal level)	9(19.6)	38(90.5)	<0.05
Mean (mg/dl)	0.23+0.22	0.55±0.35	<0.05
Range (mg/dl)	0.17-0.48	0.36-0.98	<0.05

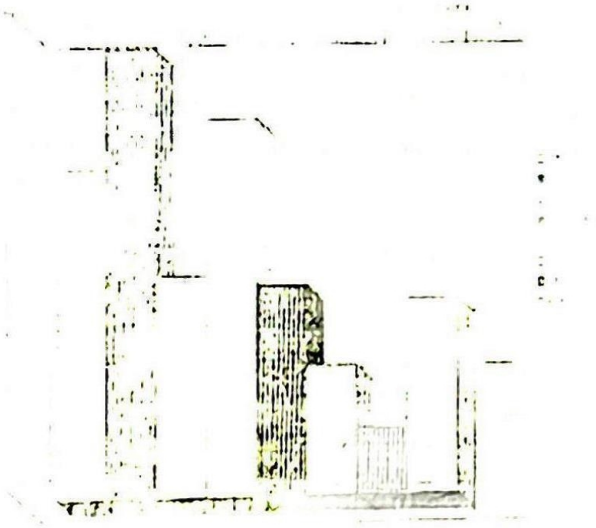

Fig. 1: The association of selected variables with the subjects serum ascorbate

Discussion

It is observed in this study that the serum ascorbate level of a high percentage of the type 2 diabetic patients attending the University College Hospital, Oyo State, Nigeria, was lower than their apparently normal counterparts (P<0.05). The significant reduction of the patients' serum ascorbate in this study may not be unrelated to the previous reports that increased production of reactive oxygen substances (ROS), which is known to impair the activity of endogenous antioxidant components, is a common complication in poorly controlled diabetes mellitus [4,5,17] Complications of diabetes mellitus such as arteriosclerosis, coronary artery disease and ischaemic tissue injury have been associated with increased uncontrolled oxidative activity, with evidence implicating reactive oxygen derived substances (ROS) in the pathogenosis of both micro and macro angiopathy [17-19].

In this study, the plasma glucose level of about two thirds of the DM patients was not controlled. That could have contributed to the low level of serum ascorbate of the DM patients. Reports indicate that hyperglycemia in diabetes mellitus results in increased generation of free radical substances

(ROS) which increases impairment in the activities of endogenous antioxidant components [5,11]. Also people with poorly controlled diabetes have high metabolic turnover, reflecting the increased conversion of ascorbic acid by oxidation to dehydroascorbic acid (DHA). There could also be competitive inhibition between glucose and ascorbic acid because of their structural similarity [9]. Free radicals are highly reactive and cause significant damage to endogenous antioxidant. They also cause oxidative damage to the body cell membranes and other cellular structures which is believed to play a major role in the complications commonly observed in diabetic patients [3,11]. Hyperglycemia could also cause reduction in renal re-absorption of ascorbic acid in persons with DM, as blood glucose may be competing with ascorbic acid for uptake into the cells and tissues [9,20].

Diabetes Mellitus is associated with a major disturbance of ascorbic acid metabolism, which can be partially corrected by ascorbic acid supplementation or increased intake of Vitamin C in food sources. There are also reports that ascorbic acid is associated with decreased production of free radicals and oxidative stress in DM patients.

In this study, the duration of DM was observed to be inversely and significantly correlated with the serum ascorbate of the DM patients. This could be as a result of the building-up of free radicals with time in the patients, as this is known to impair the activity of endogenous ascorbate components in DM patients [9].

Maintaining one's normal weight for height is associated with improved insulin sensitivity, and increased insulin secretion in obese type 2 diabetic subjects [21]. Obesity in type 2 diabetic patents was also reported to be highly associated with oxidative stress which is known to impair the activities of endogenous antioxidant component [22] Oxidative damage has also been suggested to play a major role in the development of arteriosclerosis and cardiovascular disease which are the leading causes of death and disability in obese type 2 diabetic patients [23,24]. This study has also suggested the need to maintain adequate ascorbic acid status in the DM patients as this study has shown that a high percentage of them had low serum ascorbate. Maintaining a normal serum ascorbate may be helpful for them in many ways. Ascorbic acid is known to be among the most notable non-enzymatic components of cellular antioxidant in the cytoplasm which can help to prevent long term complications of DM [17]. It is suggested that increase in plasma ascorbate is achievable through increased regular intake of fresh fruits and vegetables [9]. Studies also indicate that adults could take between 250mg and 500mg twice a day of ascorbic acid supplement for maximum benefit [20,25].

It is recommended that healthcare providers, especially doctors and dietitians, should recommend adequate amounts of ascorbic acid for diabetic patients during their medical and dietary management except for diabetic patients with renal impairment. This may help to prevent or delay vascular complications of diabetes. Diabetic patients with renal disease should consult their physician before taking vitamin C supplements as the use of excessive doses of vitamin C supplements may cause secondary oxalosis in them [26].

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