

Body Fat Content, Distribution and Blood Glucose Concentration Among Adults Population in Ilala Municipality, Dar es Salaam, Tanzania

Majili, Z.S* and J. Kinabo

Department of Food Technology, Nutrition and Consumer Science;
Sokoine University of Agriculture. Box 3006. Morogoro, Tanzania

*Corresponding author: Mobile no. +255 785100409; Email: Zahra_majili@yahoo.com

Abstract

Body fat content has been associated with increase of blood glucose concentration. The aim of this study was to examine the relationship between body fat content, its distribution and blood glucose concentration among adult population. A cross sectional survey was carried among 270 randomly selected adults, aged above 25 years. Bioelectrical impedance technique was used to determine body fat content. Waist-hip-measures were used to assess abdominal obesity. Blood glucose level was determined by GlucoPlus™ meter with a disposable blood glucose test strip. Descriptive and inferential statistics were carried out using Statistical Product and Service Solution (SPSS version 16). The mean age of the subject was 38 ± 10.5 (SD). Mean Body fat content was 27 ± 10.3 (SD). About 49% and 22% of subjects were obese and underweight respectively. About 83% of the female subjects and more than one third of the subjects aged above 35 years had a waist- hip ratio greater than 0.8. About 40% of the subjects who had fasting blood glucose level < 6.1 mmol/L, 49% of them had elevated blood glucose level 2 hours post load glucose. About 50% of subject who had greater body fat content and waist hip ratio had impaired fasting blood glucose and impaired glucose tolerant. Body fat content within the body has significance effects on blood glucose concentration. Consequently, there is a need of increasing awareness about healthy food consumption coupled with regular physical activities so as to reduce the risk of developing diet related chronic diseases.

Keywords: Body fat content, fat distribution, blood glucose level

Introduction

Body fat content has been associated with development of non-communicable diseases due to its influence on metabolic risk factors (Levitan *et al.*, 2004). Globally, the leading metabolic risk factors are high blood pressure (13%), tobacco use (9%), raised blood glucose levels (6%), physical inactivity (6%) and overweight & obesity (5%). It is estimated that 1% of rural population and 5-13% of urban population in Sub-Saharan Africa have diabetes (Motala *et al.*, 2008). In Tanzania 31% of deaths are due to non-communicable disease and 2% are due to Diabetes mellitus, 9% are due cardiovascular diseases (CVD) which are attributed to raised blood pressure (31%), raised blood glucose level (7.2%) overweight (22.1%), obesity (5.0%) and 22% due to raised cholesterol (WHO, 2014; WHO, 2011). Changes in blood glucose level are accompanied by

changes in insulin levels which may result to insulin resistance. Raised blood glucose level (Impaired glucose tolerance and impaired fasting glycaemia); overweight and obesity are risk factors for development of type II diabetes mellitus and cardiovascular disease (Levitan *et al.*, 2004).

Raised blood glucose level, overweight and obesity have great impact on men and women of working age and their elderly dependants. This results in income loss, production reduction, loss of opportunities for investment and hence lower levels of economic development (WHO, 2006a). It has been estimated that Tanzania will lose up to 3 billion dollars from premature deaths due to heart diseases, stroke and diabetes (WHO, 2005) by 2015. To overcome these problems information about causes of diabetes and its underlying factors need to be identified

and be able to develop interventions/policies to address adult morbidity and mortality due to type II diabetes mellitus. A study by Njelekela *et al.* (2003 and 2009) identified risk factors associated with development of CVDs in Tanzania. However, there is paucity of information on the relationship between body fat content, fat distribution and raised blood glucose level in Tanzania. It is hypothesised that high body fat content that is centrally distributed around the abdomen contributes in raising blood glucose level. Therefore, this study aimed at examining the relationship between body fat content, fat distribution and blood glucose concentration at Ilala Municipality, Dar es Salaam, Tanzania so as to clearly identify the linkage between body fat content, its distribution and blood glucose level. Furthermore, the obtained information will provide the basis for developing effective intervention that will lead to prevention and control of metabolic risk factors to non-communicable diseases.

Materials and methods

Study design and subjects

A cross-sectional study design was used to collect information on risk factors associated with development of diabetes from adult population residing in Ilala Municipality Dar es Salaam region (Tanzania). Subjects involved were age above 25 years, residing in Ilala Municipality not less than one year prior the commencement of the study, active and healthy.

Subject exclusion criteria

Subjects suffering from type II diabetes mellitus, hypertension, heart condition and pregnancy were excluded, because the study conditions were considered unfavourable for them like fasting 10-12 hours before the measurement.

Ethical approval

Research protocols were approved by the Research and Publication Committee of Sokoine University of Agriculture. The permission to conduct the study was granted by Ilala District authority after submission of a formal letter. Verbal informed consent was obtained from all subjects prior to the test day.

Sample size and sampling procedure

A total of 410 subjects were eligible for this study but due to known problem mentioned under exclusion criteria; only 270 randomly selected adults based on their age and sex were involved in this study. Multistage, stratified and random sampling procedures were used to obtain a representative subjects. Multistage sampling technique was used in the selection of wards; followed by the selection of villages/street whereby a random sampling procedure was used in the selection of village/street and subjects after stratifying subjects in terms of age and sex.

Measurements

Measurements of weight, height and body fat content were done on each subject. Height and weight of the subject was measured before measuring the amount of body fat content. Weight was measured using a SECA electronic scale (SECA, Germany) and recorded to the nearest 0.1kg. Subject weight was measured while wearing minimal clothing and without shoes or any accessories that may affect the measurement such as jewellery. Height of the subjects was measured while the subject was standing with back of the head, back, buttocks, calves and heels touching the upright part of the stadiometer and feet placed together while looking straight forward. The measurement was read, and recorded to the nearest 0.1cm.

Body fat measurements were conducted using the TANITA bioelectrical impedance body composition analyser (Model BF683W, Tanita Corporation of America Inc, 2625 South Clearbrook Drive, Arlington Heights, Illinois 60005 USA) which depends upon the differences in electrical conductivity of fat free-mass and fat. Subject's sex, age and height (cm) were entered onto the TANITA fat analyser, the percentage of body fat and total water were recorded when the subject stood bare feet with heels on the silver plate. The percentage body fat was then classified using body fat ranges (Gallagher *et al.*, 2000)

Waist and hip circumferences were measured using non stretchable measuring tapes

(Bouncing Rabbit, China). Subjects wore light clothes to ensure that the tape was correctly positioned at a level midway between the lower rib margin and iliac crest with the tape all around the body in a horizontal position for waist measurement. Hip circumference measurements were taken in the region of the widest segment of the buttocks. The measurements were recorded to the nearest 0.1 centimetre. The waist hip ratio (W:H) was calculated by dividing the measurement of waist to that of hip measurement and the values obtained were categorised based on the WHO (2008) cut off points.

Blood glucose determination

Condition for the subjects: The subjects were on unrestricted diet rich in carbohydrates for at least 3 days before the test as starvation or diet low in carbohydrate can lead to incorrect test result. The subjects were in the fast state overnight (10-12hrs) before the test and minimized activity such as walking or exercise on the day before and the morning of the test day. The subjects were not allowed to smoke or drink coffee on the morning of the test and during the test. The subjects were sat quietly during the test.

Fasting blood glucose (FBG): Blood glucose level was determined using the GlucoPlusTM meter (GlucoPlus Inc. Halpern, Canada) with a disposable blood glucose test strip. The capillary blood sample was drawn from the middle finger using a lancet pricker. The puncture site was disinfected and allowed to dry before applying pressure to prick the site. The Lancing device was placed firmly against the punctured site and the button released to penetrate on the site. The first two drops were wiped out so as to stimulate blood flow. The third drop was then filled in the edge of the test strip until a confirmation window was filled and a measuring symbol (a drop symbol) appeared. A fasting blood sugar was determined and recorded at time 0 (basal).

Oral glucose tolerance test (OGTT): Subjects were given a glucose solution prepared by dissolving 75grams of glucose powder in 250ml of drinking water after a test of FBG. The blood sample was then drawn followed the procedures on the FBG after every one hour for two

consecutive hours for glucose test and results were recorded in mmol/L and categorized according to WHO (2006b) recommended cut off points.

Data analysis

The data analysis was carried out using the Statistical Product and Service Solution (SPSS) version 16. Descriptive statistics such as means, and standard deviation were used to summarize continuous variable such as age, weight, height, fat content, and blood glucose levels. Frequencies were computed to summarize categorical variables such as age groups and sex, in respect, to blood glucose level, body fat content and body fat distribution. Inferential statistics such student t-test was performed to determine the significance association between glucose concentration (dependent variable) and age body fat content, waist hip ratio as an independent variable. All values were considered significant at P 0.05.

Results

Socio demographic characteristics

The characteristics of study subject are summarised in Table 1. The mean age of the subjects was 38.3 ± 10.5 years. Female subjects were younger than their male counterparts. The mean age for females was 37.9 ± 9.2 years and the mean age for males was 38.7 ± 11.8 years. About 38% of the subjects were employed; other subjects were self-employed, housewives, farmers or students. About 50% of the subjects attained a primary education few of them were graduate.

Physical characteristics

There was significant difference in weight and height among males and females subjects. The mean weight of the subjects was 67.1 ± 12.2 kg. Female subjects were slightly heavier (67.8 ± 11.3) kg than male subjects (66.4 ± 13.2) kg. The overall mean height was 1.61 ± 0.1 m; with male having a mean height of 1.6m and female subjects having a mean height of 1.59 m.

Body Mass index

The mean BMI was 25.7 ± 4.7 (SD). Body mass index varied with sex and age. Higher

Table 1: Socio-demographic characteristics for the subjects

Characteristics	Age group of respondent							
	25-34 years		35-44 years		45-54 years		55+ years	
	n	%	n	%	n	%	n	%
Sex								
Male	59	47	33	26	16	13	17	14
Female	63	43	50	35	18	12	14	10
Education								
none	2	2	0	0	5	15	8	26
Primary	67	55	53	64	19	56	11	36
Ordinary level	25	21	19	23	9	27	7	23
College/advance level	12	10	10	12	1	3	3	10
University	16	13	1	1	0	0	2	7
Occupation								
Farmer	9	7	10	12	8	24	9	29
Self employed	51	42	27	33	5	15	2	7
Employed	40	33	32	39	14	41	15	48
House wife	14	12	13	16	7	21	5	16
Student	8	7	1	1	0	0	0	0

levels of overweight were observed in females and subjects above 54 years compared to other subjects. Female (17%) and subjects of age between 45-54yrs (32%) had higher levels of obesity compared to other subjects (Fig.1).

Body fat content

The mean body fat content was $27 \pm 10.3\%$. About 49% of subjects were obese, 15% were overweight and 22% were underweight. Body fat content was significantly different between sex and age of the subjects ($p < 0.05$). Females

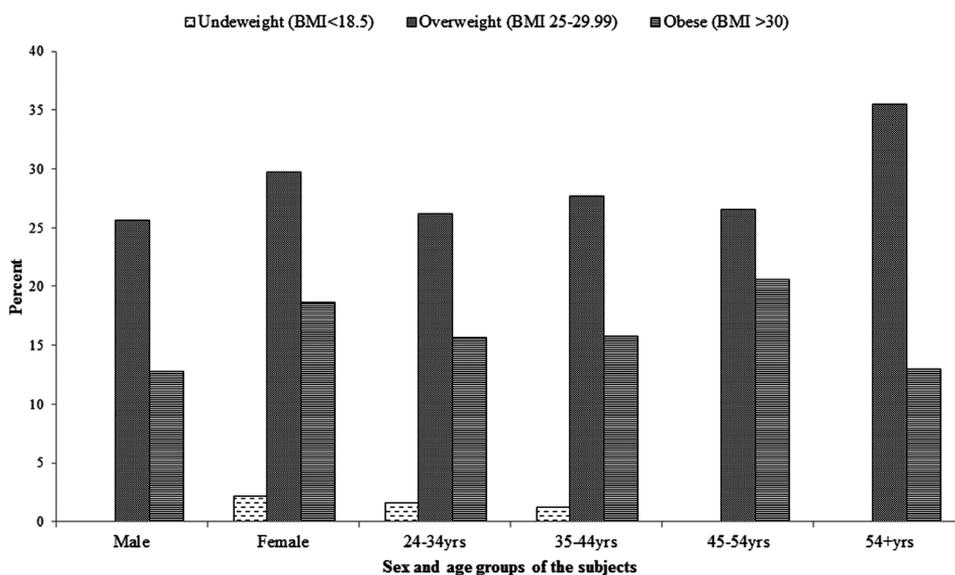


Figure 1: Nutrition status of the subject based on weight/height ratio (BMI)

had higher percentage of body fat content compared to males (Fig. 2). Similarly subjects who were above 45 years were more overweight and obese compared to other age categories

Fat distribution

The mean waist circumference for the subjects was 76.2 ± 11.0 cm. The mean waist hip ratio (WHR) was 0.8 ± 0.1 . There was a significant

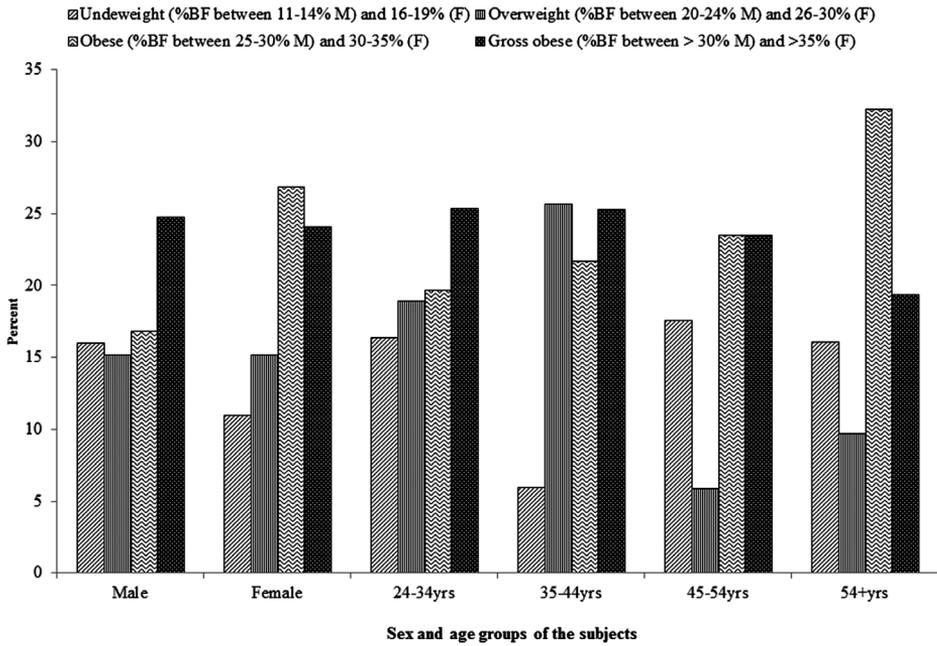


Figure 2: Nutrition status of the subject based on percent body fat content

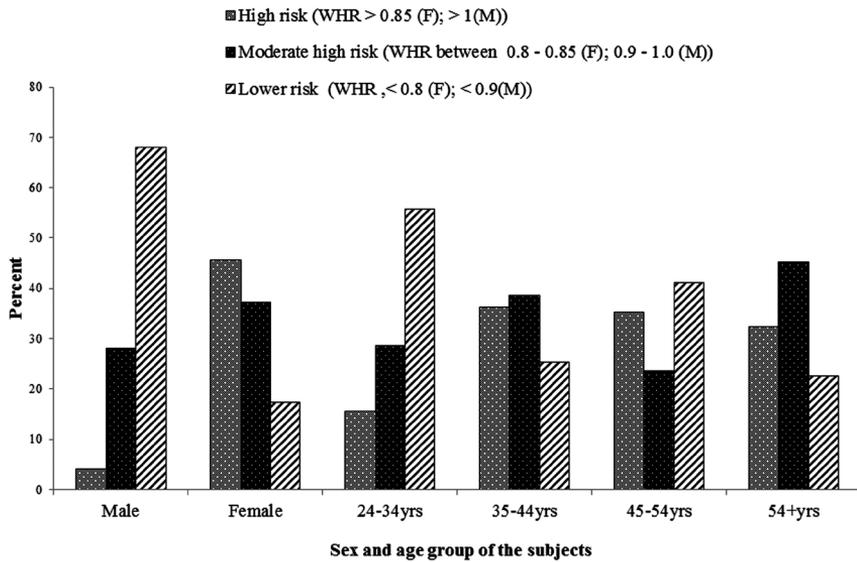


Figure 3: Waist-Hip ratio of the subjects by sex and age

difference at $p = 0.014$ in waist hip ratio between male and females subjects. About 83% of the female subjects had a waist hip ratio greater than 0.80 (Fig. 3); and more than 50% of subjects of age between 35 and 64 years had a waist- hip ratio greater than 0.85 which indicate a high risk to heart disease. Multiple comparison test (LSD) showed that there was a significant difference ($p = 0.024$) in a waist hip ratio between subjects by age. About 36%, 35% and 32% of subjects aged 35-44 years; 45-54 years and 55-64 years, respectively had a waist- hip ratio greater than 0.85 which was an indication of a high risk to heart disease

Fasting blood glucose

The mean fasting blood glucose (FBG) for the subjects was 5.9 ± 0.7 mmol/L, at 95% confidence interval, but varied with age. About 43% of subject had fasting blood glucose level between 6.1- 6.9mmol/L which is an indication of impaired fasting glucose; among them 68% of subjects above 54 years old (Fig. 4) had impaired fasting glucose (IFG). However, there was no significant difference ($p > 0.05$) in mean FBG between male and female subjects.

glucose level < 6.1 mmol/L, 49% of them had blood glucose level between 7.8 - 11.1mmol/L which indicate impaired glucose tolerance level (IGT). Blood glucose concentration was significantly different ($p < 0.05$) between subjects of different age. About 77% of subjects age above 54+ years has glucose concentration between of 7.8 to < 11.1 mmol/L which indicate impaired glucose tolerance level (IGT) (Fig. 5). However, no significant differences were observed between male and female subjects.

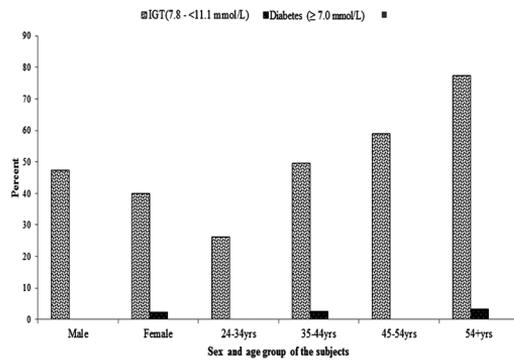


Figure 5: Two hour post load glucose concentration status

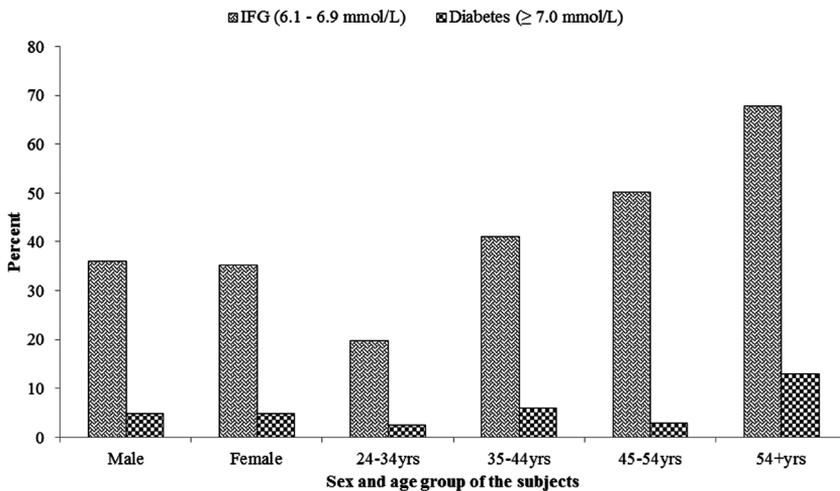


Figure 4: Fasting blood glucose concentration of the subjects

Oral glucose tolerance test

The mean glucose concentration for the subjects 2 hours post load glucose was 5.6 ± 0.4 mmol/L. Among 108 subjects who had fasting blood

Relationship between body fat content, fat distribution and Glucose concentration

Results indicate that there was little relationship between blood glucose concentration and percent

body fat (Fig. 6). Likewise, blood glucose concentration indicates weak relationship with waist hip ratio (Fig. 7). However as blood glucose concentration increase there was also an increase in body fat content and waist hip ratio.

Furthermore, about 50% of subject who were obese had fasting glucose concentration between 6.1 – 6.9mmol/L and post load glucose concentration of 7.8 – 11.1mmol/L (Table 2). Subjects who had greater waist hip ratio (56%)

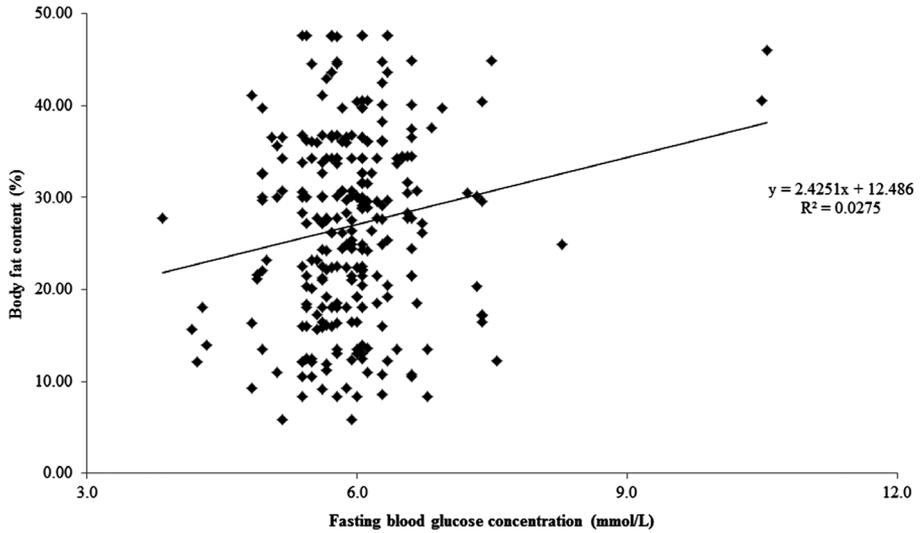


Figure 6: Relationship between body fat content and fasting blood glucose concentration

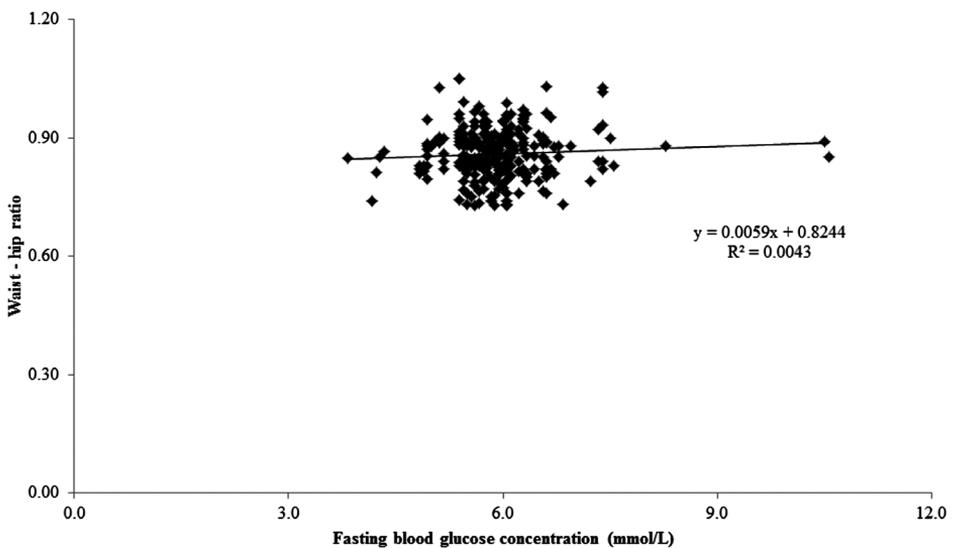


Figure 7: Relationship between waist-hip ratio and fasting blood glucose concentration

Table 2: Relationship between body fat content, fasting blood glucose concentration and 2 hour post load glucose concentration

2 hour post load glucose	% Body Fat content	Fasting glucose level			
		Impaired fasting glucose (6.1- 6.9 mmol/L)		Diabetes *(≥ 7.0 mmol/L)	
		n	%	n	%
Impaired glucose tolerance (7.8 -11.1 mmol/L)	Thin(%BF < 10%(M); <15%(F)	3	5	0	0
	Underweight (%BF 11-14%(M); 16-19%(F)	3	5	0	0
	Overweight (%BF 20-24%(M); 26-30%(F)	10	16	1	13
	Obese(%BF 25-30%(M); 30-35%(F)	18	29	3	38
Diabetes (≥ 11.1 mmol/L)	Gross obese (%BF > 30(M); >35(F)	21	34	4	50
	Overweight (%BF 20-24%(M); 26-30%(F)	1	50	0	0
	Obese(%BF 25-30%(M); 30-35%(F)	0	0	0	0
	Gross obese (%BF > 30(M); >35(F)	1	50	0	0

had also found to have glucose concentration between 6.1- 6.9mmol/L at fasting state and 7.8 - 11.1mmol/L post load glucose concentration which indicate future risk for diabetes (Table 3).

Discussion

High body fat content has been observed among female subjects particularly in working age group. This may be due to poor dietary intake

Table 3: Relationship between body fat distribution and glucose concentration

Fasting blood glucose concentration	Fat distribution	2 hour post load glucose			
		Impaired glucose tolerance (7.8 -11.1 mmol/L)		Diabetes (≥ 11.1 mmol/L)	
		n	%	n	%
Impaired fasting glucose (6.1- 6.9 mmol/L)	Moderate risk	18	39	1	100
	High risk	26	56	0	0
Diabetes (≥ 7.0 mmol/L)	Moderate risk	19	31	1	50
	High risk	27	43	1	50

coupled with low physical activities observed during survey. It has been also observed that consumption of fast foods, fried fish and potatoes, refined cereals products such as maize flour, rice and use of public transport contribute to increase in body fat content among subjects. Energy dense foods consumed by the subjects and low physical activity observed results to energy imbalances (i.e. positive energy balance) within the body hence increases chances of extra fat to be deposited within the body. Furthermore, the high body fat content observed in elderly subjects was due to some illnesses associated with their age and low/less activities due to reduction of work capability.

It has been observed that more than one third of the subjects had greater waist hip ratio. Female subjects had more fat centrally distributed around the abdomen and the risk is increasing as age increases. The high proportion of women who had higher body fat content centrally distributed was due to low physical activities and sedentary lifestyle observed during the survey; which attributed by changes in social cultural factors such as use of machine for milling, employing other people to work for them and change in diet. The mean fasting blood glucose and post load glucose concentration of the subjects was slightly lower than the minimum recommended level of 6mmol/L (FBG) and 7.8mmol/L (post load glucose concentration) for reducing diabetic complications (WHO, 2006b). However, some of the subjects had been observed to have a mean value greater than recommended. Female subjects had a slightly higher mean fasting blood glucose levels compared to male subjects. These results are associated with the large amount of fat observed in female subjects designated by a greater W: H ratio which indicates large amount of fat has been deposited around the abdomen (i.e. centrally distributed fat) which had metabolic disadvantages. This may cause insulin alterations and intracellular metabolism impairment in several tissues and hence increase risk for future diabetes.

Results showed that the risk for future diabetes increases as age increase. Large proportion of subjects aged above 45 years had impaired fasting

blood glucose concentration (6.1 to 6.9mmol/L) which indicates risk factor for future diabetes. This situation may be due to excess energy that is stored in the body in the form of fat in adipose tissue which is centrally distributed due to poor lifestyle and physiological aspects. Furthermore, there is no enough evidence in relationship between body fat content, fat distribution and blood glucose concentration. However, some of the subject who found to have impaired fasting blood glucose concentration has been also found to have high body fat content resulting from excessive weight gain and abnormal fat distribution among the subjects. Excessive weight gain and abnormal fat distribution are some of the major physiological factors associated with an increase in blood glucose level.

Conclusion(s) and recommendation

Though there was no enough evidence in relationship between body fat content, fat distribution and glucose concentration some discrepancies were observed among subject sex and age. The findings suggest that there was relationship between body fat content, fat distribution and raised blood glucose concentration as age increases and among female subjects. This was due to poor dietary intake coupled with low physical activity. Therefore, there is a need of increasing awareness about healthy food consumption coupled with regular physical activities so as to reduce the risk of developing diet related chronic diseases. This can be achieved by developing different programmes such as radio, television programmes, theatre/drama that promote healthy eating behaviour. Improved health services that allow regular medical check-ups (e.g. weekly, monthly etc.) and education will also help to reduce the disease burden.

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