Prevalence of Obesity and Dyslipidemia in Middle-Aged Men and Women in Tanzania, Africa: Relationship with Resting Energy Expenditure and Dietary Factors

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Summary The prevalence of obesity and dyslipidemia and the mean frequency of intake of selected dietary factors were studied in 545 participants aged 46–58 y and living in three areas in Tanzania. The prevalence of obesity (body mass index of ≥ 30kg/m²) was 22.5% among women and 5.4% among men, p<0.001. Higher rates of obesity were observed in both men and women in an urban (U) area of Dar. The prevalence of dyslipidemia [(TC–HDL-C)/HDL-C>5] among men was higher in a pastoralists (P) population of the Maasai in Monduli (22.6%) than in Dar (9.6%) and rural (R) Handeni (7.3%, p<0.05). The mean resting energy expenditure (REE) was higher in subjects from the rural and pastoralists populations than in urban dwellers (0.024 kcal/min/kg, p<0.001). The three areas showed different dietary patterns with subjects from the urban area consuming coconut milk (4d/wk, p<0.001) and meat (2.5d/wk, p<0.05), more often than the rural population of Handeni which had the highest consumption of green vegetables (4.2d/wk, p<0.001). Participants from Monduli had the highest consumption of milk per day (1.219 mL/d, p<0.001). A simple correlation analysis showed that body mass index (BMI) correlated positively with the frequency of intake of coconut milk, fish and meat, and negatively with REE and milk consumption. Total cholesterol (TC) was negatively correlated with the frequency of intake of green vegetables, fish and the REE, and correlated positively with meat consumption and BMI in both genders. Independent of other factors, important contributors to obesity and dyslipidemia in this population were dietary factors such as meat (p<0.001) and fish (p<0.05), and a lower REE (p<0.05). These findings suggest that unhealthy diet and lower energy expenditure are important contributors to obesity and dyslipidemia in Tanzania.

Key Words obesity, dyslipidemia, resting energy expenditure, dietary factors

Obesity can have many negative effects on health, and is associated with diabetes (1), cardiovascular disease (2), hypertension (3), osteoarthritis (4) and dyslipidemia (5). Studies conducted in Sub-Saharan Africa have reported an increase in the prevalence of obesity among both men and women in urban areas (6, 7). Other epidemiological surveys in developing countries have shown that an unhealthy diet contributes to the increasing problem of obesity (8, 9). Similarly, there has been a significant variability in the levels of dyslipidemia in the urban areas of Sub-Saharan Africa (10), and a possible increase in rural areas has also been suggested (11). Energy produced by metabolic processes in humans consists of the resting energy expenditure (REE), the thermic effect of food and physical activity-induced energy expenditure (12, 13). REE measured at rest after an overnight fast is usually the largest portion (60–75%) of the total energy expenditure. It has previously been demonstrated that increased tendencies toward obesity have been associated with a lower REE (14) and reduced physical activity (15).

This study reports on the current prevalence rates of obesity and dyslipidemia in three distinct areas in Tanzania, and further examines the most important dietary contributors to obesity and dyslipidemia in these populations.

MATERIALS AND METHODS

Data for this study was collected as part of the MONALISA (MONeo ALImentation SAnae) Study conducted in Tanzania in 1998. The MONALISA Study employed the CARDIAC Study protocol (16) and aimed at monitoring past trends of the populations previously studied during the CARDIAC study. In summary, the survey in-
volved approximately 100 men and 100 women from the three areas of Dar es Salaam, Handeni and Monduli, respectively. The Dar es Salaam region, located on the east coast of Tanzania, is the largest city, an industrial center and one of the country’s major ports. It includes the city of Dar es Salaam and other outlying areas. The study was conducted in the urban area of Temeke, whose inhabitants are mainly middle-income civil servants, petty traders and middle-class residents with moderate incomes from various other activities. The 1988 population estimate for Temeke was 405,753 people. Handeni is one of the six districts of the Tanga region, which is located in northeastern Tanzania. The 1988 population estimate for Handeni was 251,855 people. The inhabitants in this district are employed in subsistence agriculture, have a generally lower income and live a typical traditional African village life. The Monduli district is one of the nine districts in the Arusha region, which is located in northern Tanzania. The 1988 population estimate for the Monduli district was 109,292 people. Eighty-five percent of the inhabitants of Monduli are Maasai, semi-nomadic pastoralists that tend large herds of cattle and are not involved in any agricultural activities. They consume a diet rich in saturated fats, are lean and tall, and have an active lifestyle. We analyzed the number of years of formal education among the subjects in the three areas and found that the participants from Monduli had the least number of years of education (1.6±3.7 y, p<0.001).

The subjects for the survey were aged 46–58 y and were selected randomly from administrative lists obtained from ward offices. The lists were comprised of the names and ages of all the people residing in the respective areas of the study. For subjects who could not identify their age correctly, major past events were used to ascertain their age. The overall response rate was 90.8%. Participants from Monduli who did not belong to the Maasai tribe were excluded from the study. This was necessary because we wanted to study only those participants of Maasai origin, since they have been known to have a low prevalence of cardiovascular disease (CVD) risk factors. The Ethics Committee of the Muhimbili University College of Health Sciences, Dar es Salaam, approved the study protocol.

Participants came to the study location in the morning after at least a 12-h overnight fast. After obtaining informed consent, fasting blood samples were drawn for the measurement of lipids. The subjects were then instructed on how to collect 24-h urine samples using urine bags (U-Container N, Ono Medical Company, Osaka, Japan). Samples of blood and urine were shipped to the central WHO CARDIAC Study laboratory in Kyoto, Japan. Stable conditions (−20°C) were maintained during transportation to Kyoto. Standard assays were used to measure total cholesterol (TC), triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C) (Enzymatic Methods, Kit Determiner TC 555, Kyowa Medics, Tokyo, Japan). Low-density lipoprotein cholesterol (LDL-C) was calculated according to Friedewald’s Formula: LDL-C=[(TC−HDL-C)−(TG/5)] (17). Glycosylated hemoglobin (HBA1c) was determined using high-performance liquid chromatography (HPLC 723 GHb, TOSOH, Tokyo, Japan).

Anthropometric measurements included weight, height, and hip and waist circumferences. Weight and height were measured with participants wearing light clothing and without shoes. Weight was measured to the nearest kilogram using a balance scale. Height was measured to the nearest centimeter using a wall-mounted ruler. Waist and hip circumferences were measured using an anthropometric tape with the subject in standing position. Body mass index (BMI, kg/m²) was used as the index of total (general) obesity, and waist circumference and waist-to-height ratio were used as indexes of central adiposity. We used the waist circumference for analysis rather than the waist-to-hip ratio because it has been shown to have greater sensitivity (83%) and specificity (49%) with respect to central fat distribution measurements (18).

An assessment of REE was conducted for some of the participants from the three studied areas after overnight fasting. REE was estimated using Hosoya’s portable indirect calorimeter (HPIC, METAVINE, VINE Company Limited, Osaka, Japan). After a steady heart rate was achieved, the subject was asked to lie in a supine position and REE was estimated as energy expenditure in kcal/min. The final energy expenditure of an individual was adjusted to body weight and estimated as kcal/min/kg.

In order to obtain the dietary history of the participants, a questionnaire designed on the basis of a 7-d recall system was used. In summary, the subjects were asked to state the frequency of intake of selected food types and beverages commonly consumed in their African setting over 1 wk from the time an interview was conducted. The intake of milk and fermented milk was quantified in ml/d. It was estimated that a glass (commonly available in the study areas) was approximately 200 ml, and where there was the highest consumption of milk per day, we quantified the amount using a 1 L bottle.

The following definitions were used: Participants were classified as obese if their BMI was ≥30 kg/m² (19). Centrally obese subjects were those with a waist circumference of ≥88 cm for women and ≥102 cm for men (20). High TC was defined as a serum cholesterol of ≥6.2 mmol/L, concurrent with a previously published study in Tanzania (21). High LDL-C was considered LDL-C of ≥4.1 mmol/L (22), hypertriglyceridemia was a serum triglyceride level above 5.2 mmol/L (20) and low HDL-C was a HDL-C <0.9 mmol/L (22). Dyslipidemia was defined as [(TC−HDL-C)/HDL-C>5] (23). Long-standing hyperglycemia was considered if HBA1c was greater than 7% (24).

All analyses were done using Stat View statistical software (25). Participants from Monduli who were not Maasai, and those who completely failed to ascertain their age (96) were excluded. Descriptive statistics of the demographic characteristics are presented as the mean.
standard deviation (SD). The differences between the means across genders and the three centers were tested by analysis of variance, and Scheffe’s test was used for testing the significance of multiple comparisons. Significance was defined as $p<0.05$. The $\chi^2$ (Chi-square) test was used to calculate the prevalence rates of obesity, central obesity and dyslipidemia. A simple correlation analysis was used to demonstrate the relationship between obesity and lipid levels with the frequency of food intake and REE. The differences in the correlation coefficients between genders were compared by the $Z$ test. Multiple regression analysis was performed in order to identify the predictors of obesity and lipid profile in the population studied. Separate analyses were done for men and women.

**RESULTS**

The analysis included 545 individuals (259 men and 286 women). None of the subjects in any of the three populations was found to be using or have used lipid-lowering drugs. Women were found to have a higher mean BMI (men 22.5 kg/m² and women 24.7 kg/m², $p<0.001$) and a larger waist circumference (men 89.1 cm and women 92.4 cm, $p<0.05$). The overall prevalence of obesity was higher in women (22.5%) than in men (5.4%), $p<0.001$. Overall mean TC (women 4.9 mmol/L and men 4.2 mmol/L, $p<0.001$) and LDL-C (women 3.3 mmol/L and men 2.6 mmol/L, $p<0.001$) were both higher in women than in men. Women had a significantly higher prevalence of hypercholesterolaemia (19.8%, $p<0.001$) and high LDL-C (21.6%, $p<0.001$). Men showed a significantly higher prevalence of low HDL-C (34.7%, $p<0.05$). There was no significant difference in the prevalence of hypertriglyceridemia and high HBA1c across genders.

A summary of the demographic characteristics of the subjects based on the area of study and gender is shown in Table 1. Participants in Dar (U) had a significantly higher mean BMI, larger waist circumference and higher triglyceride concentration than those in the other two areas. Participants in Dar and Monduli had significantly higher TC and LDL-C levels than those in Handeni (R). The mean HDL-C levels were lowest in Handeni. The level of dyslipidemia was significantly higher among men in Monduli (P). The mean REE adjusted for body weight was significantly higher among men in Monduli and Handeni than in Dar (all, $p<0.001$). As for women, mean REE was significantly higher in Monduli than in Dar ($p=0.004$). The prevalence of obesity and central adiposity was higher in Dar than in Handeni for both men and women. The prevalence of dyslipidemia among men was higher in Monduli (22.6%, $p<0.05$) than in Dar or Handeni, while a higher prevalence of dyslipidemia was observed in women in Handeni (19.0%, $p<0.05$) than Dar or Monduli.

Table 2 summarizes the dietary patterns of subjects by days of consumption of a particular food item over 1 wk after the time of interview. The intake of coconut milk, fish and meat was highest in Dar (U). The Maasai...
in Monduli (P) commonly consumed whole milk, while green vegetables were popular among the people in Handeni (R).

Simple correlation coefficients between BMI, lipid profiles, dietary factors and REE are shown in Table 3. There was a strong positive correlation between the intake of meat \( (p<0.001) \), coconut milk \( (p<0.001) \) and fish \( (p<0.001) \) and men \( p=0.001 \) and women \( p<0.001 \) with BMI in both genders. BMI was negatively correlated with whole milk \( (women \ p<0.001) \) and with REE \( (p<0.001) \) in both genders. Men \( r=-0.276, p<0.001; \) women \( r=-0.170, p<0.05 \). In both men and women, BMI, and REE correlated positively with TC \( (p<0.001) \), triglycerides \( (p<0.001) \) and LDL-C \( (p<0.05) \) (results are not shown).

The results of multiple regression analysis between BMI and dietary factors and REE adjusted for age are shown in Table 4. We found that the frequency of eating meat \( (d/wk) \) was significantly and positively associated with BMI levels in both genders. Fish and coconut milk consumption were directly associated with BMI in men only. REE had a significant inverse association with BMI in both genders.

Table 5 shows the results of multiple regression analysis between serum total cholesterol, dietary factors and REE, adjusted for age and BMI. In all the subjects, combined BMI and meat intake in 1 wk had a positive association with serum total cholesterol, while fish intake and REE were inversely associated with serum total cholesterol. When further stratified by gender, the BMI in both men and women, fish intake among men and milk consumption among women remained as important contributors to serum total cholesterol in this population.

**DISCUSSION**

Our study is one of the few conducted in Tanzania to
show the contribution of diet and REE on obesity and serum total cholesterol levels. We have found that both general and central obesity among men were more pronounced in the urban area than in the rural and pastoralists areas. Furthermore, men from the urban area and the pastoralists' population had a greater tendency towards abnormal lipid profiles than those from the rural area. This pattern of risk factors across types of regions (urban, rural and pastoralists) suggests that some aspect(s) of Westernization of the diet may be associated with the deleterious changes in CVD risk factors.

The prevalence of dyslipidemia [(TC-HDL-C)/HDL-C>5] was found to be higher among men in Monduli (22.6%) than in Dar (9.6%) and rural Handeni (7.3%, p<0.05). People in Monduli are known for their high intake of fermented and non-fermented milk, meat and blood. It has been reported elsewhere (26) that despite this atherogenic type of diet, their TC and the incidence of cardiovascular diseases has remained low for years. There have been various explanations for this. For example, fermented milk (traditionally made yoghurt) has been found to be an important factor in lowering serum TC (27). Additionally, the Maasai pastoralists are known to include significant amounts of plant additives that contain a significant amount of hypocholesterolemic saponins and phenolics in their diets (28). The higher prevalence of dyslipidemia in Monduli was contrary to our expectations and signifies a change in the dietary behavior of the people in this area. The slightly higher dyslipidemia prevalence in urban Dar than rural Handeni is concurrent with two previous studies conducted in Africa, which demonstrated higher levels of dyslipidemia in areas of higher socioeconomic conditions (21, 29). Thus, in an African setting, despite the homogeneous type of diet rich in carbohydrates, an excess intake of dietary fats is more likely in urban populations due to the presence of higher incomes. We observed similar findings of a high frequency of intake of foods rich in fats in urban Dar where dyslipidemia and obesity were more frequent.

Diet rich in calories (meat and coconut milk) coupled with reduced physical activity may have contributed to the higher prevalence of obesity in our subjects. The increase in the frequency of intake of meat, fish and coconut milk was associated with an increase in the BMI levels, while we found a negative correlation between the intake of milk and BMI. This may explain the lowest prevalence of obesity among subjects in Monduli, who had the highest intake of milk and lowest intake of fish and coconut milk. Several other studies in Africa have shown that obesity is associated with unhealthy diet (30, 31). In Dar, fish is eaten more regul-
larly deep fried in coconut milk. It is commonly eaten as a relish with a high carbohydrate food called "Ugali." In one study where rats were repeatedly fed fish fried in coconut oil, it was observed that weight, total lipid and cholesterol in the heart and serum cholesterol showed a tendency to increase (32). Thus, the difference in the pattern of consumption of various dietary factors led to the differences observed in the mean BMI levels and the prevalence of obesity and central adiposity between the urban and rural areas and the pastoralists' population.

Lower REE was another contributor to obesity in our study population. The mean REE was higher in Monduli than in urban Dar. Furthermore, we have demonstrated a strong negative relationship between REE and BMI in both men and women. This suggests that there is a high level of physical inactivity, thus lower REE, in people in Dar as compared to Monduli or Handeni. The mean REE adjusted for body weight was also lower in women who were obese (results are not shown). Two other studies have demonstrated lower REE in obese women (14, 33).

In conclusion, the higher obesity prevalence in the urban area and the higher prevalence of dyslipidemia among pastoralists as well as among urban dwellers indicate that these two populations are in varying stages of nutritional transition from their traditional diets. The introduction of nutritional education in Tanzania will be of importance for arresting the obvious consequences of caloric excess and diets high in fats and animal products. Public health efforts must focus not only on eradicating malnutrition in Africa, but also on preventing obesity, hypercholesterolemia and their consequences.

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REFERENCES


