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M. A. Njelekela, MD, H. Negishi, MSc, Department of Life Science, Environmental Conservation and Development, Graduate School of Human and Environmental Studies, Kyoto University, Japan, Y. Nara, PhD, Graduate School of Integrated Science and Art, University of East Asia, Shimonoseki, Japan, T. Sato, MD, Matsuda Red Cross General Hospital, Tokyo, Japan, M. Tomohiro, PhD, S. Kuga, MSc, T, Noguchi, PhD, T. Kanda, PhD, M. Yamori, DDS, Department of Life Science, Environmental Conservation and Development, Graduate School of Human and Environmental Studies, Kyoto University, Japan, Y. Mashalla, PhD, Department of Physiology, Muhimbili University College of Health Sciences, P. O. Box 65001, Dar es Salaam, Tanzania, L. Jian Liu, PhD, K. Ikeda, PhD, Department of Life Science, Environmental Conservation and Development, Graduate School of Human and Environmental Studies, Kyoto University, Japan, J. Mtabaji, PhD, Department of Physiology, Muhimbili University College of Health Sciences, P. O. Box 65001, Dar es Salaam, Tanzania and Y. Yamori, PhD, Department of Life Science, Environmental Conservation and Development, Graduate School of Human and Environmental Studies, Kyoto University, Japan.

Request for reprints to: Dr M. A. Njelekela, Graduate School of Human and Environmental Studies, Kyoto University, Yoshida Nihonmatsu-cho, Sakyo-ku, 606-8501, Kyoto, Japan.

OBESITY AND LIPID PROFILES IN MIDDLE AGED MEN AND WOMEN IN TANZANIA

M. A. NJELEKELA, H. NEGISHI, Y. NARA, T. SATO, M. TOMOHIRO, S. KUGA, T. NOGUCHI, T. KANDA, M. YAMORI, Y. MASHALLA, L. JIAN LIU, K. IKEDA, J. MTABAJI and Y. YAMORI

ABSTRACT

Objective: **To examine the relationship between obesity and lipid profiles and to compare the effects of total obesity and central adiposity on lipids in three locations in Tanzania.**
Design: **Cross-sectional epidemiological study.**
Setting: **Three areas in Tanzania: Dar es Salaam (urban), Handeni (rural) and Monduli (pastoralists), in August 1998.**
Subjects: **Five hundred and forty five men and women from a random sample of 600 people aged 46-58 years.**
Main outcome measures: **Mean BMI, waist circumference, WHR, TC, HDL-C, LDL-C, TG and LDL/HDL ratio. Prevalence rates of overweight, obesity, central obesity and dyslipidaemia.**
Results: **As compared to men, women had higher BMI (24.7 versus 22.5 kg/m^2, $p<0.0001$), waist circumference (92.4 versus 89.1 cm, $p< 0.05$), TC (4.9 versus 4.2 mmol/L, $p<0.0001$) and LDL-C (3.3 versus 2.6 mmol/L, $p<0.0001$). The urban population demonstrated higher levels of lipid factors than the rural population (TC, men 4.8 mmol/L; women 5.3 mmol/L, $p<0.0001$; TG, men 3.6 mmol/L; women 3.7 mmol/L, $p<0.0001$, LDL-C, men 2.8 mmol/L, $p<0.0001$). BMI and waist circumference correlated positively with serum TC, TG, and LDL-C in both genders. Stepwise regression analysis showed that BMI predicted triglyceride concentration in men ($p< 0.05$) and women ($p<0.0001$). Waist circumference predicted levels of TC in women only ($p<0.0001$) and of LDL-C in both genders (men $p<0.05$, women $p<0.0001$). The prevalence of overweight, obesity and central obesity were significantly higher in urban than in rural areas in both men and women. Compared to lean subjects, obese men and women had significantly higher mean serum TC, TG, LDL-C and a higher prevalence of dyslipidaemia. The mean levels of TC, TG and LDL cholesterol increased across successive increases in BMI and waist circumference quintiles in both genders.**
Conclusion: **Subjects from the urban area had greater lipid abnormalities related to obesity than those from the rural area and that, central adiposity had a greater effect on total cholesterol and LDL cholesterol among women than was BMI.**

INTRODUCTION

Obesity can have many negative effects on health, being associated with diabetes(1), cardiovascular disease(2), hypertension(3), osteoarthritis(4) and dyslipidaemia(5). Various lipid abnormalities have been found in obese individuals, including elevated levels of serum total cholesterol, triglycerides and lower high-density lipoprotein cholesterol. Of these indicators, changes in triglyceride and HDL cholesterol are the most consistent and pronounced(6). Other studies have demonstrated that central obesity is more strongly related to lipid abnormalities than general obesity(7). In a recent survey of obesity among women in developing countries, it was found that in poor countries in sub-Saharan Africa, obesity was concentrated more in urban areas and among educated women than in rural areas. Besides, the prevalence of obesity was lower than that in Latin America and the Caribbean, the middle of Africa and North Africa(8). Other studies from sub-Saharan Africa have reported an increase in the prevalence of obesity among both men and women in urban areas(9,10). Similarly, there has been a significant variability in the levels of dyslipidaemia in urban and rural areas in sub-Saharan Africa(11), and a possible increase in rural areas has also been suggested(12). Most of the reported surveys from Tanzania have not been able to describe the more important lipid abnormalities found among obese individuals, nor the different effects of central adiposity and general obesity on lipid profiles. Thus, this study investigated the relationship between obesity and lipid profiles and compared the effects of total obesity and central adiposity on lipids in an African population.

MATERIALS AND METHODS

Study design: The CARDIAC Study (CARDIAC; World Health Organisation Cardiovascular Disease and Alimentary Comparison Study), which was conducted in Tanzania in 1987(13), was cross sectional epidemiological survey designed to investigate the relationship between dietary factors and blood pressure(14). The survey involved 100 men and 100 women from three centres of Dar es Salaam, Handeni and Monduli. Data for this study were collected as part of a repeat CARDIAC study data collection in Tanzania, in 1998. Subjects were aged 46-58 years, and were selected randomly from an administrative list. Six hundred and seventy nine individuals responded to the invitation, but only 545 subjects were included in this analysis as we excluded all participants from Monduli who did not belong to the Maasai tribe.

Assessment of subjects and definitions: This consisted of a questionnaire interview, a physical examination and collection of blood and urine specimens. Participants reported in the morning after at least a 12-hour overnight fast. After obtaining informed consent, fasting blood samples were drawn for the measurement of lipids. Subjects were then instructed about how to collect 24-hour urine samples by using urine bags (U-Container N, Ono Medical Company, Osaka, Japan). All the samples of blood and urine were shipped to the central WHO CARDIAC Study laboratory in Kyoto, Japan and standard assays were used to measure total cholesterol, HDL cholesterol and triglycerides (enzymatic methods, Kit determiner TC 555, Kyowa Medics, Tokyo, Japan). LDL cholesterol was calculated according to Friedewald' s Formula: LDL cholesterol = Total cholesterol - HDL cholesterol - (Triglyceride/5) (15).

Anthropometric measurements included weight, height, hip and waist circumference. 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 centimetre using a wall-mounted ruler. Waist and hip circumferences were measured with an anthropometric tape with the subject standing. BMI (kg/m^2) was used as the index of total (general) obesity and waist circumference was used as the index of central adiposity. We chose to use waist circumference for detailed analysis rather than the waist to hip ratio because it has been shown to have greater sensitivity (83%) and specificity (49%), in respect to central fat distribution measurement(16). Besides, waist circumference appears to be comparable with the waist to hip circumference ratio, waist circumference to height ratio and sagittal diameter in assessing metabolic risk profile related to fat distribution(17). The following definitions were used: overweight – a body mass index of ≥ 25 kg/m^2 (18); obese – a body mass index of ≥ 30 kg/m^2 (18); centrally obese – waist circumference of ≥ 88 cm in women or ≥ 102cm in men (19); lean – a body mass index of $<25 kg/m^2$ (18); cholesterol – we divided serum total cholesterol into the following categories according to a previously published study in Tanzania(20): normal as < 5.2 mmol/L; moderate as ≥ 5.2 and < 6.5 mmol/L and high ≥ 6.5 mmol/L; LDL cholesterol – elevated LDL cholesterol was assessed as those subjects with LDL concentration > 2.97 mmol/L (21) and; triglycerides – hypertriglyceridemia was defined as a serum triglyceride level above 5.2 mmol/L according to Okosun *et al*(19).

Statistical analysis: All analyses were done using Stat view statistical software(22). Participants from Monduli who were not Maasai (n= 96) were excluded. None of the participants were using lipid-lowering drugs. Therefore, a total of 545 subjects (259 men and 286 women) were included in the analysis. The descriptive statistics of demographic characteristics were presented as the mean ± standard error (SE). The difference between the means across genders and the three centres was tested by analysis of variance. Statistical significance was defined as $p < 0.05$. BMI and waist circumference were stratified into quintiles and the lipid profile of the subjects in each of the categorised quintiles was assessed. The significance of the lipid level differences between quintiles was tested by ANOVA. Partial correlation analysis was used to demonstrate the relationship between obesity and lipid levels. The differences in the correlation coefficients between genders were compared by the Z test. Regression analysis was performed in order to identify which measures of obesity were the best predictors of lipid profile. The effect of diet, smoking and exercise was not part of this analysis. Separate analyses were conducted for men and women.

RESULTS

Complete sets of data were collected for 545 individuals, (after exclusion of those from Monduli centre who were not of Maasai origin, as we wanted to evaluate this remote population in its native context as traditional eating habits are thought to have been preserved). None of the subjects in any of the three populations were found to use lipid-lowering drugs. Women were found to be more obese than men, BMI (men 22.5 kg/m^2 and women 24.7kg/m^2 ($p<0.0001$)) and had a higher waist circumference (men 89.1 cm, women 92.4 cm ($p<0.05$)). Women also showed a higher prevalence of hypercholesterolaemia and LDL cholesterol than men. Women had significantly higher serum total cholesterol (men 4.2 mmol/L, women 4.9 mmol/L, ($p<0.0001$) and LDL cholesterol (men 2.6 mmol/L, women 3.3 mmol/L ($p<0.0001$) than men. No gender difference was found for HDL cholesterol, triglycerides and the atherogenic index. A summary of the demographic characteristics of the subjects is shown in Table 1. Participants from the urban area of Dar es Salaam had significantly higher mean BMI, waist circumference, waist to height ratio and triglyceride than those from the other two centres. Participants from Dar es Salaam and Monduli had significantly higher serum total cholesterol and LDL cholesterol levels than those from Handeni. The mean HDL cholesterol levels were lowest in Handeni. There were no significant differences observed in the LDL/HDL cholesterol ratio calculated for each of the three areas.

Table 1

Demographic characteristics of the subjects by gender and area

Characteristics	Dar (n=181)		Handeni (n=218)		Monduli (n=146)	
	Men	Women	Men	Women	Men	Women
Number (n)	(89)	(92)	(111)	(107)	(59)	(87)
Age (years)	51.8±0.4	52.1±0.4	52.0±0.4	52.2±0.4	50.6±0.6	50.6±0.4$^{\delta}$
Body mass index (kg/m^2)	25.2±0.5	28.6±0.7	21.3±0.3***	24.3±0.6***	20.7±0.4***	21.0±0.5***
Waist circumference (cm)	94.1±1.0	97.5±1.6	85.3±0.7***	90.5±1.4*	88.8±1.0**	89.4±1.2**
Waist/Height ratio	0.57±0.1	0.64±0.0	0.52±0.0	0.59±0.0***	0.52±0.0	0.56±0.1***
Total cholesterol (mmol/l)	4.8±0.1$^{\delta\delta\delta}$	5.3±0.1$^{\delta\delta\delta}$	3.4±0.1	4.4±0.1	5.1±0.2$^{\delta\delta\delta}$	5.3±0.1$^{\delta\delta\delta}$
Triglycerides (mmol/l)	3.6±0.3	3.7±0.2	2.1±0.1***	2.2±0.1***	1.9±0.2***	1.7±0.1***
LDL cholesterol (mmol/l)	2.8±0.1$^{\delta\delta\delta}$	3.2±0.1	2.0±0.1	3.0±0.1	3.7±0.2***$^{\delta\delta\delta}$	3.7±0.1$^{\delta\delta}$
HDL cholesterol (mmol/l)	1.2±0.0$^{\delta\delta}$	1.3±0.0$^{\delta\delta}$	1.0±0.1	1.0±0.0	1.1±0.1	1.3±0.0$^{\delta\delta\delta}$
LDL/HDL ratio	3.4±1.0	2.5±0.1	2.4±0.2	3.6±0.4	4.3±0.7	3.7±0.4

Values are mean±Standard Error (S.E.)

***$^{\delta\delta\delta}$ P<0.0001; $^{\delta\delta}$** p<0.001; *$^{\delta}$ p<0.05; *vs Dar; $^{\delta}$ vs Handeni

Partial correlation coefficients between BMI, waist circumference and lipid profiles are shown in Table 2. In both men and women, BMI correlated positively with serum total cholesterol ($p<0.0001$), triglycerides ($p<0.0001$), and LDL cholesterol ($p<0.05$). Waist circumference correlated positively with serum total cholesterol (men $p<0.05$, women $p<0.0001$), triglycerides ($p<0.05$), and LDL cholesterol (men $p<0.05$, women $p<0.0001$). There was no positive correlation between HDL cholesterol and BMI or waist circumference.

Table 2

Correlation coefficients between general and central obesity and lipid levels for men and women

Lipids	BMI r	BMI p	Waist Circumference r	Waist Circumference p
Men				
Total cholesterol	0.312	<0.0001	0.312	<0.0015
Triglycerides	0.360	<0.0001	0.259	<0.0091
LDL cholesterol	0.190	0.0031	0.321	0.0012
HDL cholesterol	0.042	0.5127	-0.003	0.9774
Women				
Total cholesterol	0.257	<0.0001	0.462	<0.0001
Triglycerides	0.391	<0.0001	0.268	<0.0058
LDL cholesterol	0.186	0.0026	0.468	<0.0001
HDL cholesterol	0.021	0.7373	0.059	0.5416

Values are correlation coefficients (r)

In order to evaluate the most important determinants of lipid levels among the alternative measures of general and central obesity, stepwise regression analysis was conducted. Table 3 shows regression coefficients for a model that includes each of the lipids as dependent variables with obesity measures as independent variables. BMI predicted triglyceride concentration in both men and women (men $p<0.05$, women $p<0.0001$) while waist to height ratio had no effect on lipid profiles in either gender. Waist circumference predicted levels of total cholesterol in women only ($p<0.0001$) and of LDL cholesterol in both men and women (men $p<0.05$, women $p<0.0001$). We found an inverse relationship between obesity and HDL cholesterol in men but none among women. However, it was not statistically significant.

Table 3

Regression coefficients for the relationship between BMI, waist circumference and lipid profiles among men and women.

Model	Total cholesterol	Triglycerides	LDL cholesterol	HDL cholesterol
Men (n=238)				
BMI	-0.051	0.067*	-0.038	-0.088
Waist Circumference	0.048***	0.019	0.042*	-0.002
Waist to Height Ratio	-0.060	0.015	-0.062	-0.022
Women (n=251)				
BMI	0.076	0.106***	-0.020	0.099
Waist Circumference	0.061***	-0.048	0.055***	0.059
Waist to Height Ratio	-0.021	-0.009	-0.035	0.031

Values are presented as coefficients of regression.

*** p<0.001

** p<0.001

* p<0.05

The prevalence of obesity (BMI $\geq$30kg/m^2) was higher in Dar es Salaam in both men 10.3% ($p<0.05$) and women 40.0% ($p<0.0001$), than either in Handeni or Monduli. When the whole sample was pooled, the prevalence of obesity was found to be higher among women than in men, 22.5% versus 5.1% ($p<0.0001$). As for lipid profiles, women generally showed a higher prevalence of hypercholesterolaemia (men 6.9%, women 14.3%, $p<0.0001$) and of high LDL cholesterol (men 42.7%, women 63.1%, $p < 0.0001$) than men. There were no significant differences in the prevalence of high TG, low HDL or high LDL/HDL ratio in men and women.

Table 4

Lipid profile and prevalence of hyperlipidemia among lean and obese men and women

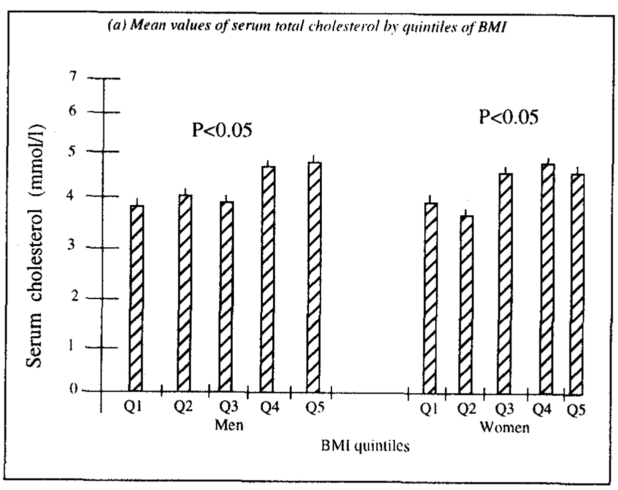
Lipid profile	Men		Women	
	Lean (n=195)	Obese (n=13)	Lean (n=170)	Obese (n=63)
Total cholesterol (mmol/L)	4.0 ± 0.1	5.3 ± 0.5*	4.6 ± 0.1	5.7 ± 0.2***
Triglycerides (mmol/L)	2.1±0.1	4.8±1.1***	2.0±0.1	3.7±0.3***
LDL cholesterol (mmol/L)	2.5 ± 0.1	3.2±0.5	3.1±0.1	3.8±0.2*
HDL cholesterol (mmol/L)	1.1±0.0	1.1±0.1	1.2±0.0	1.2±0.0
Hypercholesterolaemia (TC ≥6.5 mmol/L)	5.3%	18.2%*	9.9%	25.0%**
Elevated LDL (LDL > 2.97 mmol/L)	32.4%	45.5%	48.7%	77.2%*
Hypertriglyceridaemia (TG ≥5.2 Mmol/L)	2.7%	33.3%***	0.6%	17.5%***
Low HDL cholesterol (HDL ≤0.9 mmol/L)	38.3%	27.3%	29.8%	18.3%

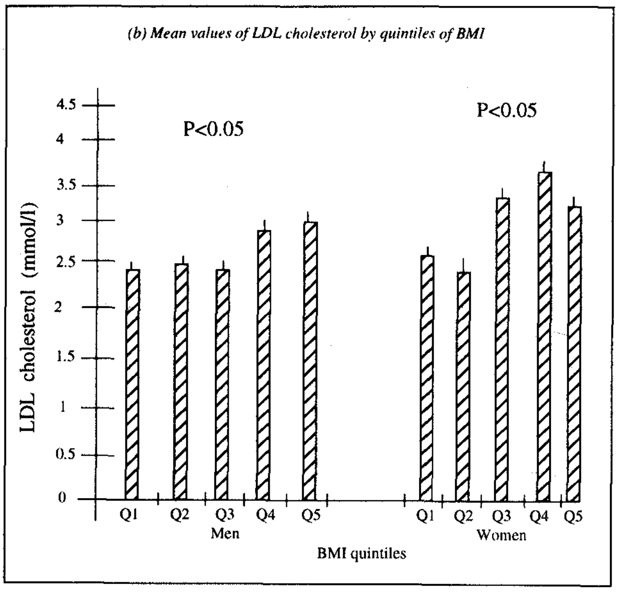
Values are mean ± S.E (Standard Error) or as percentage (%)
*** p<0.0001; ** p<0.001; * p<0.05; Lean BMI<25kg/m^2; Obese BMI ≥30kg/m^2

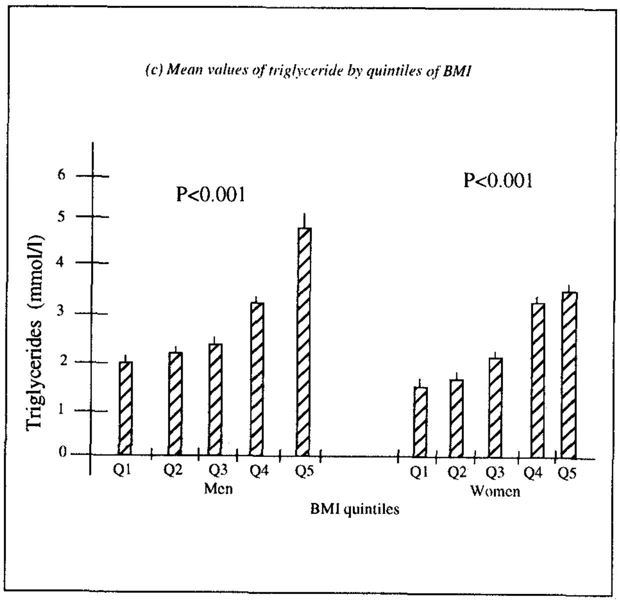
The means and prevalence of dyslipidaemia for the groups of lean and obese men and women are summarised in Table 4. Both obese men and women had significantly higher mean serum cholesterol and triglycerides than did lean subjects. Obese women, but not obese men, had significantly higher mean LDL cholesterol than lean subjects. No differences were found between lean and obese subjects in terms of HDL cholesterol. In addition, obese men and women had a higher prevalence of hypercholesterolaemia and hypertriglyceridemia. Obese women, but not obese men, had a higher prevalence of elevated LDL cholesterol. There was no significant difference in the prevalence of low HDL cholesterol in either lean or obese subjects.

Figure 1

Body mass index (kg/m^2) and lipid levels in an African population. Bars show mean values and whiskers show 95% confidence intervals. TC, LDL cholesterol and TG of men and women: Men Q1 ≤19.4; Q2 19.5-21.4, Q3 21.5-24.8; Q4 24.9-28.4, Q5 ≥28.5. Women Q1 ≤19.3, Q2 19.4-22.3, Q3 22.4-28.7, Q4 28.8-33.4, Q5 ≥33.5







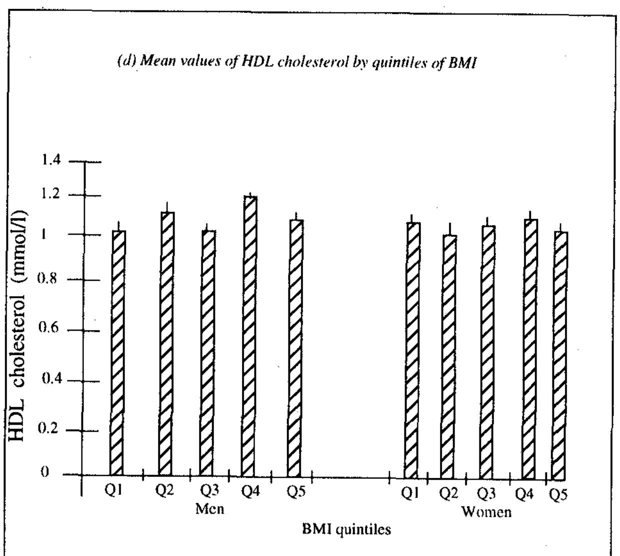
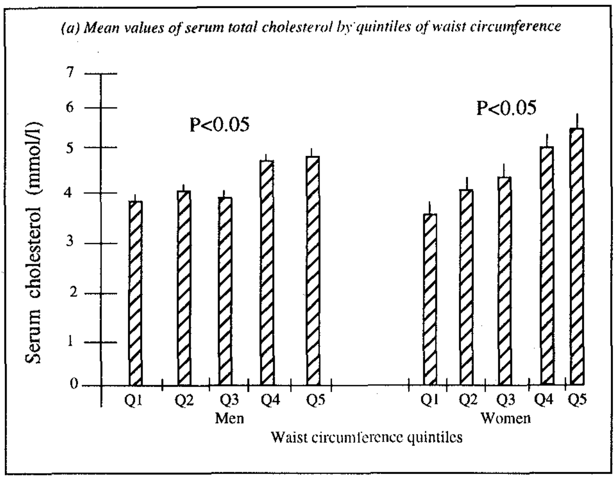
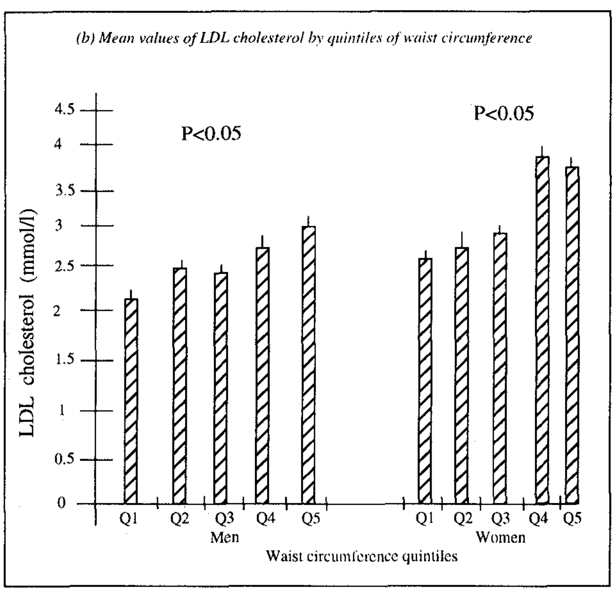
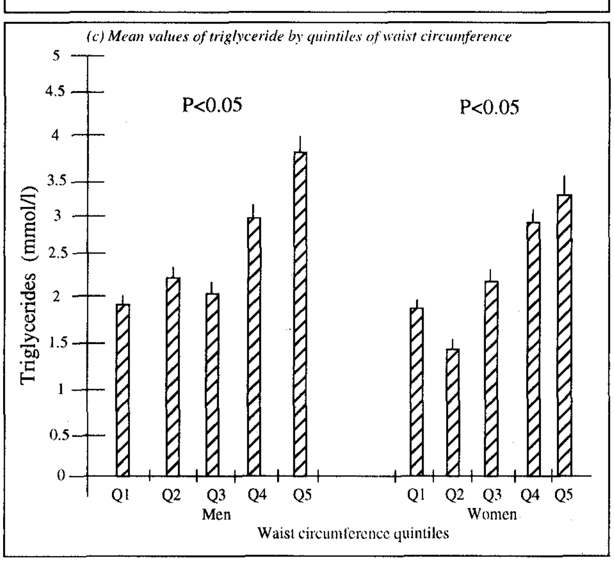


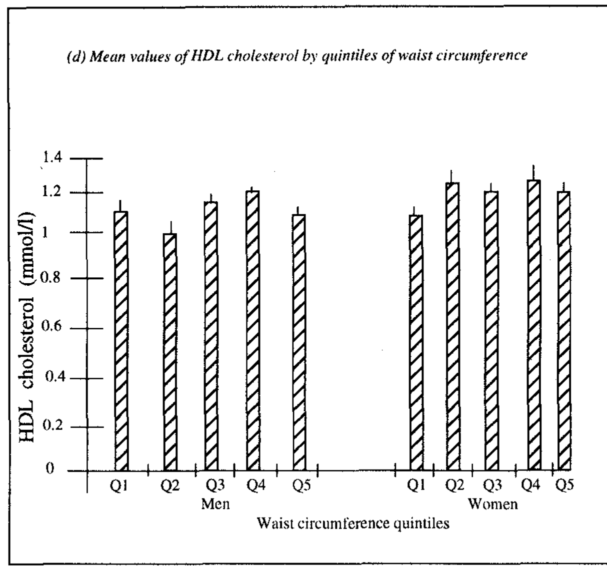
Figure 2

Waist circumference (cm) and lipid levels in an African population. Bars show mean values and whiskers show 95% confidence intervals. TC, LDL cholesterol, TG of men and women: Men Q1 ≤82, Q2 83-87, Q3 88-93, Q4 94-101.3, Q5 ≥101.4. Women Q1 ≤81, Q2 82-89, Q3 90-101, Q4 102-110, Q5 ≥111









Figures 1 and 2 show lipid levels by quintiles of BMI and waist circumference, respectively. Mean levels for serum total cholesterol, triglycerides and LDL cholesterol were higher with each increase in quintiles of BMI and waist circumference in both genders. The mean HDL cholesterol showed a declining trend only at the highest levels of both body mass index and waist circumference in both men and women. The significance of the difference in the means of lipid levels at increasing quintiles of BMI and waist circumference was stronger with BMI than with waist circumference in the case of triglycerides among women.

DISCUSSION

Our study is one of the few in Tanzania to examine the relationship between obesity and lipid profiles, and to compare the effects of total obesity and central adiposity on lipid levels in an African population. The results of our study indicated that general obesity and central adiposity are more pronounced in urban areas than in rural populations, and that obese subjects had a greater tendency towards abnormal lipid profiles than lean individuals. Also, women were more affected than men. There have been various other observations in Africa which have indicated that obesity seems to be concentrated in the urban areas rather than in rural populations(8,9,19,23). In developing economies, lifestyle changes towards westernisation in urban populations have partly caused an increase in the prevalence of cardiovascular diseases in the urban areas(24). However, a more recent study in Tanzania(12) reported an increase in both the prevalence of obesity and that of hypertension in both urban and rural populations. Furthermore, we found a high prevalence of obesity and central adiposity among women in the poor rural area of Handeni. This could be an indication of how, in rural areas of Tanzania, obesity and central adiposity can result in an equivalent burden of disease as that seen in urban areas.

Likewise, the prevalence of dyslipidaemia was higher in urban than rural areas in both genders. One study conducted in Tanzania several years ago showed a low level of dyslipidaemia in rural Tanzania and higher levels in the northern area of Kilimanjaro, Tanzania, which has relatively higher social economic conditions despite its remoteness from the urban lifestyle(20). In a study on lipid profiles conducted in Nigeria(10), it was found that urban populations had more of an atherogenic lipid profile than the rural populations mainly because the urban population had higher social economic conditions. Thus, despite the homogeneous type of diet rich in carbohydrates and low in fats eaten in most of the African countries south of the Sahara, an excess intake of dietary fats is more likely in urban populations. We also observed similar findings of a high intake of foods rich in fats in the urban area of Dar (results were not presented). However, a high serum total cholesterol level among men in the nomadic Maasai from Monduli was contrary to previous studies conducted in the Maasai area(13,25). The Maasai are known for their high intake of both fermented and non-fermented milk, meat and blood. It has been reported elsewhere that, despite this atherogenic diet, their serum total cholesterol and incidence of cardiovascular diseases has remained low for years(25). There have been various explanations for this. For example, fermented milk has been found to be an important factor in lowering serum cholesterol(26,27). The possible mechanism suggested is through an increase in human gut bacteria content. These bacteria digest complex carbohydrates to produce short chain fatty acids (SCFAs), which decreases circulatory cholesterol concentrations either by inhibiting hepatic cholesterol synthesis or redistributing cholesterol from plasma to the liver(28). Hence, it was expected from this study that the Maasai would demonstrate low serum total cholesterol levels. The Maasai are also known to include significant amounts of plant additives in their milk, blood and soup. These additives have been found to contain a significant amount of hypocholesterolaemic soponins and phenolics(29). Thus, the reason for an increase in the serum total cholesterol among men in the Maasai tribe might have been either due to an additional intake of dietary fat, a reduction in fermented milk consumption or a reduction in their intake of plant dietary additives, which have a potent anticholesterolaemic effect. Further investigation are needed to identify important contributing factors to the dyslipidaemia among the Maasai.

Some studies have shown positive relationships between central adiposity and lipid profiles across gender(30). We demonstrated that, on the basis of gender, waist circumference had a stronger effect on total and LDL cholesterol in women than men. Paccaud *et al*(31), demonstrated a higher sensitivity of waist circumference among women than men. BMI was associated with adverse triglyceride concentrations in both genders. Hence, these data may support the view that high WC may be useful for mass screening of dyslipidaemia in Tanzania. Furthermore, we observed a more significant increase in TG and TC cholesterol with increasing quintiles of measures of obesity in either gender. This was consistent with a recent study(5). It, therefore, indicates that increasing both BMI and waist circumference tend to influence the distribution of lipids among subjects in Tanzania.

In our study women were more affected with adverse lipid levels than men. Other studies have demonstrated similar findings concerning dyslipidaemia(5,30). The population of women we investigated included a fraction of post-menopausal women, in whom the protective effect of oestrogen on lipid metabolism was not effective. This could explain the high prevalence of both central and general obesity and the higher prevalence of hypercholesterolaemia and LDL cholesterol in women than in men.

LDL cholesterol is known to be the most notorious particle in the development of atherosclerosis(21). Several other studies conducted in Africa have shown a positive association between LDL cholesterol and measures of adiposity(10,11), whereas some studies have failed to detect such a relationship(32). Other studies have shown that in older women, excess body weight was associated with less excessive levels of LDL cholesterol and that LDL cholesterol was not influenced by body weight in older men(33,34). We demonstrated a stepwise increase in mean levels of LDL cholesterol in the first four quintiles of both BMI and waist circumference (but a lower level in the most obese quintile in women). Men showed a consistent stepwise increase in mean LDL cholesterol with rising quintiles of both BMI and waist circumference. It may be that, increasing BMI influences LDL cholesterol in a bimodal fashion, with very large amounts of fat causing a decrease in LDL cholesterol. An explanation for this could be a simultaneous increase in the clearance of LDL cholesterol in adipocytes in the most obese people(35). It might also be due to the fact that adipose tissue convert adrenal androgens to oestrogen, which can lower LDL cholesterol. Because our study was a cross sectional survey, no causal associations can be assumed, and such hypotheses need to be tested by other means, including the use of longitudinal data.

The relationship between HDL cholesterol and measures of obesity showed an unusual pattern. We failed to demonstrate an inverse relationship between HDL cholesterol and measures of obesity among women. Other studies have demonstrated a strong negative correlation between BMI and waist circumference with HDL cholesterol in either gender(5,36,37). Despite increasing obesity, HDL cholesterol levels were high in moderate obesity, tending to decrease only with severe obesity. This could be partly explained by the simultaneous intake of dietary fibres and magnesium by the participants which may mask the decrease in HDL cholesterol.

In conclusion, we have demonstrated the main lipid abnormalities related to obesity in Tanzanian men and women, which included high serum cholesterol, high triglycerides and high LDL cholesterol. General obesity had a similar effect on lipids in both men and women and the effect of central obesity on changes in lipid levels were found to be stronger among women than men. Generally, women were more obese and dyslipidaemic than men. In addition to BMI, waist circumference can be used as accurately in the evaluation of cardiovascular risk factors in Tanzania. Finally, this study demonstrated the urgent need for effective strategies for primary prevention and treatment of obesity and dyslipidaemia in Tanzania.

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