BMJ Nutrition, Prevention & Health

Prevalence and sex-specific patterns of metabolic syndrome in rural Uganda

Limor Ben-Yacov,[1] Pearl Ainembabazi,[1] Aliza Hannah Stark,[1] Samuel Kizito,[2] Silver Bahendeka[3]

To cite: Ben-Yacov L, Ainembabazi P, Stark AH, *et al*. Prevalence and sex-specific patterns of metabolic syndrome in rural Uganda. *BMJ Nutrition, Prevention & Health* 2020;**3**:e000050. doi:10.1136/bmjnph-2019-000050

[1]School of Nutritional Sciences and the International School of Agricultural Sciences, The Hebrew University of Jerusalem, Rehovot, Israel
[2]Clinical Epidemiology Unit, Makerere University College of Health Sciences, Kampala, Uganda
[3]Medical School, Uganda Martyrs University, Kampala, Uganda

Correspondence to
Dr Limor Ben-Yacov, School of Nutritional Sciences, Hebrew University of Jerusalem, Rehovot 76100, Israel; limor.ben-yacov@mail.huji.ac.il

Received 28 August 2019
Revised 4 November 2019
Accepted 29 November 2019
Published Online First 2 January 2020

Check for updates

ABSTRACT

Background and aims In sub-Saharan Africa, infectious diseases are still the leading causes of mortality; however, this may soon be surpassed by non-communicable illnesses, namely hypertension, diabetes and cardiovascular disease. This study determined the prevalence and patterns of metabolic syndrome and cardio-risk factors in men and women in rural Uganda.

Methods A household-based, cross-sectional survey was carried out following the WHO STEP-wise approach to surveillance. It included demographic and lifestyle questionnaires, anthropometric measurements and biochemical analyses. Of the 200 randomly recruited participants, 183 successfully completed two steps of the study and 161 provided blood samples.

Results Data were collected from 183 adults, aged 18–69 years; 62% were female. Based on the National Cholesterol Education Program-Adult Treatment Panel-III criteria, the prevalence of metabolic syndrome was 19.1% (95% CI 14.0 to 22.5). Elevated fasting plasma glucose was observed in 14.2% (95% CI 9.1 to 19.3) of participants, hypertriglyceridaemia in 16.9% (95% CI 12.1 to 23.1); hypertension in 36.1% (95% CI 29.0 to 43.0) and 52.5% (95% CI 45.2 to 59.6) had low HDL (high-density lipoprotein) cholesterol. Abdominal obesity was found in 24.6% (95% CI 18.8 to 31.4) of participants. Sex disparities were significant for several risk factors. Females had significantly higher prevalence of abdominal obesity (38.6% vs 1.5% in males, p=0.001) and twice the rates of low HDL (65.8% vs 30.4%, p=0.001). Men tended to have higher but not significant rates of hypertension (42.0% vs 32.5%) and smoked significantly more than women (49.3% vs 21.1%, p<0.001). Alcohol consumption was also higher in men (55.1% vs 18.4%, p<0.001) and quantities consumed were approximately three times greater than in females (p<0.001).

Conclusion Metabolic syndrome exists at worrying rates in the rural Ugandan population. Sex disparities are evident in risk factor prevalence, reflecting physiological variables and deeply entrenched cultural and lifestyle norms.

What this paper adds

- A high prevalence of metabolic syndrome was documented in a rural Ugandan adult population.
- Distinct sex-specific patterns of metabolic syndrome were identified.
- Sex specific disparities in metabolic syndrome components and other cardiovascular risk factors were consistent with findings from other Sub-Saharan countries.

INTRODUCTION

Metabolic syndrome (MetS) is a group of risk factors that increases the likelihood of developing cardiovascular disease (CVD). In the USA, the National Cholesterol Education Program (NCEP III) defines metabolic syndrome as the presence of at least three of the following risk factors: abdominal obesity, elevated plasma fasting glucose, increased blood pressure, elevated plasma triglycerides (TG) and low levels of plasma high-density lipoprotein cholesterol (HDL-C).[1] Additional cardiovascular risk factors have been documented including: low levels of physical activity, high body mass index (BMI), smoking and alcohol consumption.[1 2] CVDs are the leading cause of death globally.[3] Furthermore, the Global Status Report on Non-Communicable Diseases documented that three quarters of all CVD deaths and the majority of premature deaths (82%) occur in low-income and middle-income countries like Uganda.[3 4]

In the 1950s, coronary heart disease was virtually non-existent in Uganda.[4] However, mortality rates from non-communicable diseases (NCDs) are rising and have reached an estimated 27%,[4] with heart disease currently listed by the Global Burden of Disease Study among the top 10 causes of death in Uganda.[5] Infectious diseases such as malaria and HIV/AIDS remain the leading causes of death, but intensive efforts are being made to improve disease outcomes. These changes in disease prevalence, with the rise of NCDs, reflect an epidemiologic transition.

Indeed, findings from the National Non-Communicable Diseases Risk Factor Survey, that was carried out in Uganda in 2014, documented 26.4% and 36.9% rates of hypertension and prehypertension, respectively.[6] Even more disquieting was that only 7.7% of participants were aware of their blood pressure status.[7]

Other risk factors, such as low HDL-C, have also been documented in rural areas of Uganda with rates of prevalence as high as 71.3% in the adult population.[8] Additionally, in recent population-based surveys, 2.0%–8.6% prevalence rates of impaired fasting glucose and 1.4%–7.4% prevalence of diabetes mellitus have been reported.[9 10]

Although the individual risk factors for CVD have been well documented in Uganda, similar data on the prevalence of MetS are not available. Yet, MetS is considered to be more predictive of NCDs and a valuable measure for identifying both new onset diabetes and CVD.[11] Several underlying factors are considered responsible for the development of MetS and insulin resistance is central to metabolic physiological disruption. Insulin resistance is linked to elevated free fatty acid levels. In addition, it is responsible for abnormal adipokine profiles such as adiponectin, which effects glucose metabolism and leptin activity.[12]

To the best of our knowledge, no study has been designed with the objective of determining the prevalence of metabolic syndrome among a random sample of adults in rural Uganda.

METHODS

Study population and design

A cross-sectional study was carried out in two representative districts (Ntungamo and Sheema) in rural south western Uganda. Sampling techniques that were used in selecting study participants included the probability proportional to size technique[13] for random sampling and the KISH Grid method.[14] A household was defined as a group of people living and eating together.[9] A single resident member was selected from each household without replacement.[14] Inclusion criteria were males or non-pregnant females, aged 18–69 years, of African Ugandan descent, who had lived in the villages for the past 6 months. Exclusion criteria included history of or current mental illness or inability to provide informed consent.

Demographics, anthropometric and laboratory measurements

Data collection followed an abridged version of the WHO STEP-wise approach to surveillance (STEPS) method.[15]

Step 1 involved administering a questionnaire to collect information on social demographics, including marital status, level of education, occupation and housing conditions. Lifestyle assessment was determined based on previously validated questions regarding tobacco use,[6] alcohol use[6 16] and physical activity.[17]

Step 2 of the WHO STEPS was carried out by taking physical measurements such as weight, height, waist and hip circumference[18] and blood pressure.[15] All readings were measured in triplicate and the average of the three taken as the final value, except for blood pressure, where the first reading was discarded. Waist circumference was measured to the nearest 0.1 cm using a non-stretchable standard tape measure. The waist was identified as the point mid-way between the lowest rib and the top of the iliac crest on exhalation.[18]

Step 3 was the collection of fasting blood samples from participants. Plasma glucose levels were measured with Haemocue analyzers using finger prick drawn blood. In addition, 5 mL of venous blood was drawn from each participant into a vacutainer bottle. Samples were centrifuged and the serum was transported on ice packs to St. Francis Hospital Laboratory, in Kampala. Samples were stored at −70°C. The serum sample was analysed for HDL-C and TG.

Physical activity levels were determined by estimating minutes per week achieved from moderate-intensity and vigorous-intensity activities for work, transportation and leisure, based on WHO criteria.[17]

Definitions

Participants with a reading ≥100 mg/dL were considered to have elevated fasting plasma glucose, a reading ≥100 mg/dL to <126 mg/dL was classified as prediabetes and ≥126 mg/dL was classified as diabetes.[1] Elevated TG were defined as ≥150 mg/dL, low HDL-C as <40 mg/dL in men or <50 mg/dL in women.[1] Individuals that reached at least 600 metabolic equivalent of task were classified as physically active.[17]

Metabolic syndrome was defined according to the ATP/NCEP III definition,[1] as presence of any three of the following: waist circumference ≥102 cm in men or ≥88 cm in women; blood pressure ≥130 ≥85 mm Hg; fasting blood glucose ≥100 mg/dL; TG≥150 mg/dL and low HDL-C <40 mg/dL in men or <50 mg/dL in women.

Statistical analyses

Continuous variables were summarised using mean±SD, and the categorical variables were summarised using frequencies and proportions, with the corresponding 95% CIs. Logistic regression models were used to determine factors associated with metabolic syndrome. Multivariate logistic regression was performed to determine how the independent variables were jointly associated with the outcome. Variables with a p≤0.2 at bivariate analysis were considered for the multivariate model. The variables were entered into a stepwise logistic model. Interaction between the variables which remained in the model was assessed using the Chunk test. This was then followed by assessing for confounding using a difference of ≥10% between the crude and adjusted measure of effect (OR) for the variables that would have gone out at each step. Significance was set at p<0.05. The goodness of fit of the final models was assessed using the Hosmer and Lemeshow Statistic, using the estat gof command in Stata V.14.1 (Stata, College Station, Texas, 2015).

Table 1 Demographics of the study population

Variable	Overall proportion (n) n=183	Male proportion (n) n=69	Female proportion (n) n=114	P value
Age (years) Mean±SD	44.2±13.1	44.5±14.7	44.1±12.2	0.576
Marital status				
Married	73.2% (134)	88.4% (61)	64.0% (73)	**<0.001**
Single	8.7% (16)	10.1% (7)	7.9% (9)	
Divorced/separated	4.4% (8)	0% (0)	7.0% (8)	
Widowed	13.7% (25)	1.5% (1)	21.1% (24)	
Highest level of education attained				
No formal education	23.5% (43)	15.9% (11)	28.1% (32)	**0.001**
Primary	48.1% (88)	40.6% (28)	52.6% (60)	
Secondary	20.8% (38)	27.5% (19)	16.7% (19)	
Tertiary	7.6% (14)	15.9% (11)	2.6% (3)	
Housing (proxy wealth indicator)				
Lives in a house with solar power	44.2% (81)	44.9% (31)	43.8% (50)	0.839
Iron sheets, concrete walls, no solar	38.8% (71)	36.2% (25)	40.4% (46)	
Iron sheets, mud and wattle walls, no solar	11.5% (21)	11.6% (8)	11.4% (13)	
Mud and wattle, grass thatched, no solar	5.5%(10)	7.3% (5)	4.4% (5)	

Bold values represent significant differences (p< 0.05)

Ethical approval

The study was approved by the St. Francis Hospital Review and Ethics Committee (Document No. UG-REC-020) and the Uganda National Council of Science and Technology (Document No. HS2218). Information leaflets which were translated into the local language (Runyankole) were provided and individuals were asked for written informed consent before they participated in the study. In cases where the consent could not be expressed in writing, oral consent was obtained.

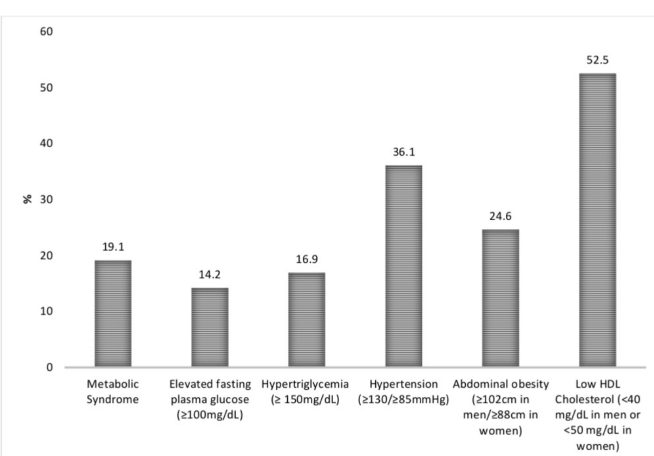

Figure 1 Prevalence of metabolic syndrome and its components in rural residents in Uganda (n=161). HDL, high-density lipoprotein.

RESULTS

Out of the 200 recruited participants, 183 successfully completed two steps of the study and 161 completed all three steps. Seventeen individuals declined to participate, and 22 did not complete the blood draw. Demographic characteristics are summarised in table 1.

The mean age of participants was 44 years, ranging from 18 to 69 years with no significant difference between sexes. More than half of the participants were female (62%), married (73%) and had completed at least primary education (75%). Almost half (44%) of the study population reported to have access to solar power, which reflects a socioeconomic status above the poverty line.[19]

Prevalence of metabolic syndrome and its components for participants (n=161) are shown in figure 1. Overall, 19.1% (95% CI 14.0 to 22.5) of the study population met the criteria for metabolic syndrome. Notable results include 52.5% (95% CI 45.2 to 59.6) of participants with low levels of HDL-C and 36.1% (95% CI 29.0 to 43.0) of participants with hypertension. Significant differences in the prevalence of specific risk factors between sexes were also observed as presented in figure 2. Twice as many women than men were documented with low HDL (p=0.001). In addition, almost all the cases of abdominal obesity were measured in women (p=0.001). Men tended to have higher rates of hypertension and elevated TG, but results did not reach statistical significance.

Evaluation of modifiable CVD risk factors using a multivariate analysis, adjusted for: age, sex, smoking status, physical activity, housing status, self-reported family history of diabetes or hypertension, indicated that overweight participants (29.9≥BMI ≥25.0 kg/m^2) had 11.2

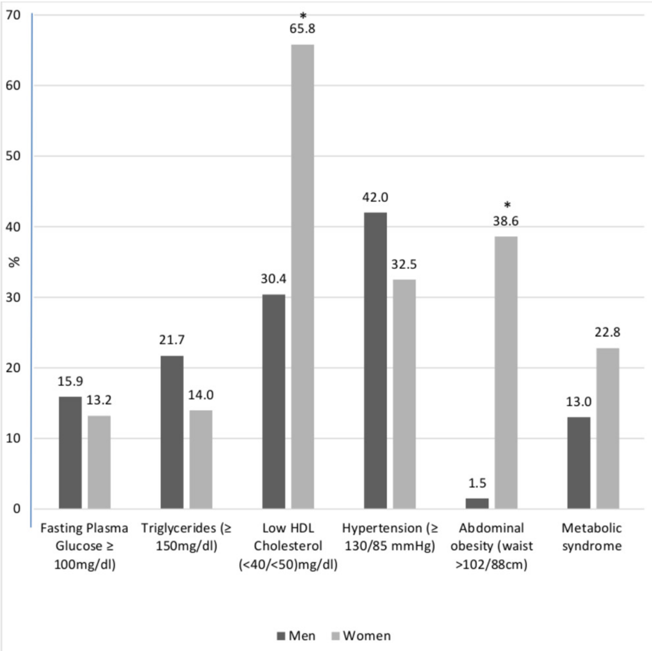

Figure 2 Prevalence of the components of metabolic syndrome in rural Ugandans (n=161) by sex. HDL, high-density lipoprotein.

times greater odds of being diagnosed with metabolic syndrome (95% CI 2.8 to 44.9, p=0.001) compared with participants in the normal BMI range (18.5–24.9 kg/m^2). Likewise, obese participants (BMI ≥30 kg/m^2) had 20.3-fold increased odds for metabolic syndrome (95% CI 3.4 to 122.5, p=0.001).

The prevalence of additional risk factors of metabolic disease such as BMI, smoking, alcohol consumption and physical activity status are not part of the NCEP-ATP III criteria. This data are presented in table 2.

Half of the participants had a normal BMI, while around 40% had elevated weight. Significantly more women were classified as overweight than men (27.2% vs 15.9%, p=0.001) and all documented cases of obesity were found only in women (26.3%, p=0.001).

The majority of the participants (83.1%) met WHO recommendations for physical activity. Almost a third of the population were current or ever smokers. However, 79.2% of females reported that they had never smoked. Men smoked more than twice as much as women (49.3% vs 21.1%, p<0.001) and the majority of both male smokers (94.1%) and female smokers (79.2%) smoked on a daily basis. Differences in the mode of tobacco use were found with nearly all men smoking cigarettes or pipes while more women chewed tobacco (p=0.004, table 2). A third of the overall population also reported that they were current drinkers. Most of drinkers were men (55.1% vs 18.4% in women, p<0.001), and, when drinking, men consumed three times more alcohol compared with women (p<0.001).

DISCUSSION

This study is the first population-based study, in a representative sample of adults, to document that metabolic syndrome (MetS) exists at a disturbing rate of 19% in rural Uganda. Previous assessments documented 4%–14%; however, study populations included children as young as 13[20] or patients with AIDS.[21]

The major risk factors identified in this study were: reduced levels of HDL-C, hypertension and high waist circumference, a variable not reported in the National 2014 Survey.[6] An intriguing picture was revealed when comparing the prevalence of cardio-risk factors between men and women (figure 2). Although the difference in the overall prevalence of MetS by sex did not reach significance, distinctive, sex-specific patterns of the three most common risk factors were noteworthy. Females accounted for almost all the cases of abdominal obesity (39% vs 2% in males) and twice as many women than men were identified with low HDL levels (66% vs 30%). In addition, there was a distinct trend towards higher rates of hypertension in males (42%) compared with their female counterparts (33%).

Similar to the findings of this study, Asiki *et al*[8] reported low HDL-C levels in Ugandan women with rates of 79% in women vs 61% in men. Another variable exhibiting substantial sex differences in the current study was abdominal obesity. This result confirmed the work of Murphy and colleagues who reported abdominal obesity rates of 2% in rural Ugandan men vs 30% in women.[20] Last, the current results of 29% more hypertension in males compared with females, though not significant, are supported by findings of in the Ugandan National Survey, where 14% greater risk of hypertension was documented in males.[6] Prevalence of MetS in adults has also been reported in other sub-Saharan African (SSA) countries, including Ghana (12%),[22] Cameroon (11%)[23] Kenya (35%)[24] and Tanzania (38%).[25] Surprisingly, some of these rates are comparable to the USA with approximately 34% of the population suffering from MetS.[26 27] This may reflect adaptation of unhealthy Western lifestyle practices in African countries. Although these data have been reported for both urban and rural settings, there is no agreement regarding the impact of place of residence on MetS prevalence. Heterogeneity in results may be explained by variable socioeconomic status and rapid changes in environmental factors.[28]

In order to verify the possibility of a sex-specific pattern for metabolic disorders, comparisons to other studies in SSA countries were made. Higher prevalence of low levels of HDL in women in comparison to men has repeatedly been documented. In Nigeria, rates of 83% were determined in women compared with 52% in men,[29] while Kenya reported 72% in women vs 45% of men.[24] Tanzania documented low levels of HDL-C in 48% of females and 22% of males.[25] In contrast, and not in line with our study results, the National Survey in Uganda[6] reported overall equal rates of 61% low HDL-C in both male and female Ugandan subjects living in rural areas.

Table 2 Life style characteristics of the study population by sex

Variable	Overall percentage (n) n=183	Male percentage (n) n=69	Female percentage (n) n=114	P value
BMI				
Normal	49.2% (90)	63.8%(44 44))	40.4%(46 46)	
Underweight	11.5% (21)	20.3% (14)	6.1% (7)	
Overweight	23.0% (42)	15.9% (11)	27.2% (31)	**0.001**
Obese	16.4% (30)	0% (0)	26.3% (30)	**0.001**
Smoking status				
Never	68.3% (125)	50.7% (35)	78.9% (90)	**<0.001**
Current or ever	31.7% (58)	49.3% (34)	21.1% (24)	
Type of smoking (of smokers*)				
Puff cigarettes/pipe	79.3% (46)	94.1% (32)	58.3% (14)	**0.004**
Chewing tobacco leaves	13.8% (8)	2.9% (1)	29.2% (7)	
Both chews and puffs	6.9% (4)	2.9% (1)	12.5% (3)	
Frequency of smoking*				
Daily	87.9% (51)	94.1% (32)	79.2% (19)	**0.085**
Intermittent	12.1% (7)	5.9% (2)	20.8% (5)	
Alcohol status				
Current drinkers	32.2% (59)	55.1% (38)	18.4% (21)	**<0.001**
Past drinkers	23.0% (42)	21.7% (15)	23.7% (27)	
Never drinkers	44.8% (82)	23.2% (16)	57.9% (66)	
Quantity of drinking†				
1–2 standard drink‡ a day	35.6% (22)	13.1% (5)	80.9% (17)	**<0.001**
3–5 standard drinks a day	50.8% (29)	65.8% (25)	19.1% (4)	
>5 standard drinks a day	13.6% (8)	21.1% (8)	0.0% (0)	
Physical activity				
Meets WHO recommendation				
No	16.9% (31)	15.9% (11)	17.5% (20)	0.779
Yes	83.1% (152)	84.1% (58)	82.5% (94)	

Bold values represent significant differences (p< 0.05)
*Of current or ever smokers.
†Of current drinkers.
‡Standard drink of alcohol: any alcohol drink that contains 10 g pure alcohol (WHO 2000). Equivalents of 1 standard alcoholic drink include; 285 mL (one bottle) of beer, 100 mL glass of wine (factory distilled or locally brewed) and 30 mL glass of a spirit or gin (factory distilled or locally brewed).[16]

Abdominal obesity has also been documented to be sex-specific in several studies in SSA countries, with substantially higher rates in women. It is considered to be the high-risk body fat pattern, as this adipose tissue is particularly active hormonally, secreting a wide variety of adipokines. It is associated with greater insulin resistance and dyslipidaemia.[30] In Benin 54% of women were identified with abdominal obesity vs 11% in men.[31] Two studies in urban Tanzania showed a five times higher prevalence rates among women (58% vs 11% and 35% vs 7%).[25 32] Moreover, following logistic regression analyses of the Tanzanian data, women had 14.2–fold increased odds for abdominal adiposity than men (95% CI 5.8 to 34.6).[25] Abdominal obesity, in all these studies, was defined using the WHO criteria of waist circumference ≥102 cm in men and ≥88 cm in women.[18]

Since the best cut-off point has been widely debated, in particular for individuals living in SSA, some studies have used a more stringent standard of ≥94 cm in men and ≥80 cm in women.[33] This was the case in a Kenyan study that reported prevalence of abdominal obesity in 70% of urban women vs 30% in urban men.[24] In Cameroon, 33% of females and only 4% of males suffered from abdominal obesity. The participants in Cameroon were relatively young, 20–25 years old, with an overall rate of MetS of 11%.[23]

Sex differences in the prevalence of hypertension, though not significant in this study, were still 29% higher in men than women. This trend was supported by a significant 14% higher rate of hypertension in men, found in 3906 Ugandans participating in the National Survey.[6] In an additional study, this CVD risk factor was significantly lower among women than men (OR 0.67) as determined in 2011 participants from northwestern Tanzania and southern Uganda.[34] Additional studies from Tanzania[24] and Kenya[23] report the same pattern, indicating that hypertension is more prevalent in men in SSA.

Possible mechanisms responsible for the sex-specific risk factors of CVD include inactivity, tobacco use, alcohol intake and obesity.[35] These are all common behavioural risk factors for NCDs which we found to be prevalent at significantly different levels in African men and women. However, in this study, physical activity levels were similar for both sexes (table 2). It should be noted that there is disagreement regarding the WHO methodology for measurement of physical activity, which has been shown to have low validity in Africa.[36]

Data reported here indicate that men smoked significantly more than women and drank alcohol significantly more than women. These results are in line with the Ugandan 2014 National Survey. Adjusting for age, sex, region of residence and ethnicity, males were found to consume twice as much alcohol as women (OR=2.34, 95% CI 1.88 to 2.91).[16] Similar results on higher rates of smoking and alcohol consumption in men have been published for urban Tanzania,[25 32] Benin[31] and other SSA countries.[37] Lifestyle behaviours, such as higher rates of smoking in men, have known hypertensive effects, including stimulating the sympathetic nervous system, which leads to arterial stiffness.[38]

Overweight and obesity, along with higher rates of abdominal obesity, were the major factors contributing to high rates of MetS identified in females. Although dietary consumption was assessed in this study, due to the challenges of collecting data in populations with limited literacy, it was not possible to accurately determine total energy and nutrient intake. However, a dietary diversity score was calculated and was similar in both sexes (data not shown). Female gender has previously been documented as a predictor of overweight and obesity in periurban and rural Uganda[39] along with other SSA countries. For example, in Tanzania, women had 4.3 greater odds of obesity than men.[25 32] This is most likely linked to a multitude of African social and cultural factors.[38] When a young Ugandan woman is being prepared for marriage, her diet and activity are planned in ways guaranteed to increase her weight.[25 39] The bride-to-be is not allowed to carry out heavy physical activity and is encouraged to eat large quantities of food. Interestingly, higher rates of abdominal obesity in women have also been documented in the USA, despite social and cultural pressures promoting a slim body image. This sex gap in abdominal obesity has intensified in the last decades, reaching 70% in American woman vs 41% in men in 2014.[27]

Hyperglycaemia is also part of the MetS. Although significant sex differences were not observed in this study, the prevalence of diabetes has been reported to be higher in women compared with men across all age groups in SSA.[28] This contradicts the hypothesis that higher levels of oestrogen in women are thought to protect pancreatic beta cells.[40] In this study, other factors, such as significantly more smoking in men, may have contributed to similar data documented for both men and women.

This study has many strengths. Participants were randomly recruited and sample size had sufficient power to reach significant results. The use of biochemical data and anthropometric measurements allowed for objective documentation without relying on self-reported data. Study limitations included challenges associated with carrying out research in rural African settings, characterised by populations with low levels of education. This was reflected in distrust and superstition, which possibly led to individuals' unwillingness to participate in a study that involved drawing blood. It is likely that some participants believed that researchers were investigating topics related to HIV,[41 42] which may have reduced compliance. Therefore, the study staff did not ask about HIV status or use of antiretroviral drugs.

In conclusion, metabolic syndrome exists at worrying rates in the rural Ugandan population. Distinct sex-specific patterns of risk factors for MetS and CVD were documented and are likely due to complex interactions of lifestyle behaviours, physiological variables and cultural influences. Despite the rapid increase in prevalence of NCDs in SSA, awareness of the problem is still low. Thus, multidisciplinary interventions to reduce risk factors should be a top priority at all healthcare levels taking into consideration disparities between men and women.

Acknowledgements The authors would like to thank the men and women in Uganda who consented to participate in this study. In addition, the study would not have been possible without the financial support of the Pears Foundation (UK) and The Hebrew University of Jerusalem, International School of Agricultural Sciences who provided a scholarship for Ms Ainembabazi in her MSc studies. DAS Handling Ltd, Uganda, also provided partial financial support for this study.

Contributors LB-Y was involved in all stages of the research. She was responsible for the overall planning and design of the study, data interpretation and drafting the initial manuscript. PA was an MSc student on this project and participated in study design, was responsible for data and sample collection and processing and final review of the manuscript. AHS served as a consultant throughout the research and was involved in manuscript writing. SK performed statistical analysis and final review of the manuscript. SB was involved in the study design, was responsible for laboratory analyses and supervising the field work from start to finish. He also critically reviewed the final version of the manuscript.

Funding This study was funded by Pears Foundation (UK), DAS Handling Ltd (Uganda).

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

REFERENCES

1 National Cholesterol Education Program. Third report of the National cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III) final report. *Circulation* 2002;106:3143–421.
2 American Heart Association. Metabolic syndrome, 2016. Available: https://www.heart.org/en/health-topics/metabolic-syndrome/about-metabolic-syndrome [Accessed 4 Jul 2019].
3 World Health Organization (WHO). Global status report on non-communicable diseases, 2014. Available: http://www.who.int/nmh/publications/ncd-status-report-2014/en/.pdf [Accessed 4 Jul 2019].
4 World Health Organization (WHO). Non-Communicable diseases (Ncd) Uganda profile. Available: http://www.who.int/nmh/countries/uga_en.pdf?ua=1.pdf [Accessed 4 Jul 2019].
5 Institute for Health Metrics and Evaluation. Global burden of diseases profile: Uganda, 2017. Available: http://www.healthdata.org/uganda.pdf [Accessed 4 Jul 2019].
6 Ministry of Health. Non-Communicable disease risk factor survey, Uganda report, 2014. Available: https://www.health.go.ug/content/non-%C2%ADcommunicable-disease-risk-factor-baseline-survey.pdf [Accessed 4 Jul 2019 4].
7 Guwatudde D, Mutungi G, Wesonga R, *et al*. The epidemiology of hypertension in Uganda: findings from the National non-communicable diseases risk factor survey. *PLoS One* 2015;10:e0138991.
8 Asiki G, Murphy GAV, Baisley K, *et al*. Prevalence of dyslipidaemia and associated risk factors in a rural population in south-western Uganda: a community based survey. *PLoS One* 2015;10:e0126166.
9 Bahendeka S, Wesonga R, Mutungi G, *et al*. Prevalence and correlates of diabetes mellitus in Uganda: a population-based national survey. *Trop Med Int Health* 2016;21:405–16.
10 Mayega RW, Guwatudde D, Makumbi F, *et al*. Diabetes and pre-diabetes among persons aged 35 to 60 years in eastern Uganda: prevalence and associated factors. *PLoS One* 2013;8:e72554.
11 Grundy SM. Pre-Diabetes, metabolic syndrome, and cardiovascular risk. *J Am Coll Cardiol* 2012;59:635–43.
12 Lam DW, LeRoith D. Metabolic Syndrome. In: Feingold KR, Anawalt B, Boyce A, eds. *Endotext*. South Dartmouth (MA): MDText.com, Inc, 2000.
13 Turner AG. *Sampling strategies. Handbook on designing of household sample surveys*. Geneva: United Nations Statistics Division, 2003.
14 Kish L. *Survey sampling*. New York: John Wiley and Sons, 1965.
15 World Health Organization. Who steps surveillance manual: the who stepwise approach to chronic disease risk factor surveillance, 2005. Available: https://apps.who.int/iris/handle/10665/43376.pdf [Accessed 4 Jul 2019].
16 Kabwama SN, Ndyanabangi S, Mutungi G, *et al*. Alcohol use among adults in Uganda: findings from the countrywide non-communicable diseases risk factor cross-sectional survey. *Glob Health Action* 2016;9:31302.
17 World Health Organization. Global physical activity questionnaire (GPAQ). analysis guide, 2012. Available: https://www.who.int/ncds/surveillance/steps/GPAQ_EN.pdf [Accessed 4 Jul 2019].
18 World Health Organization. Waist circumference and waist–hip ratio: report of a who expert consultation, 2008. Available: https://www.who.int/nutrition/publications/obesity/WHO_report_waistcircumference_and_waisthip_ratio/en. pdf [Accessed cited 2019 July 4].
19 Lay J, Ondraczek J, Stoever J. Renewables in the energy transition: evidence on solar home systems and lighting fuel choice in Kenya. *Energy Economics* 2013;40:350–9.
20 Murphy GAV, Asiki G, Young EH, *et al*. Cardiometabolic risk in a rural Ugandan population. *Diabetes Care* 2013;36:e143.
21 Muyanja D, Muzoora C, Muyingo A, *et al*. High prevalence of metabolic syndrome and cardiovascular disease risk among people with HIV on stable art in southwestern Uganda. *AIDS Patient Care STDS* 2016;30:4–10.
22 Ofori-Asenso R, Agyeman AA, Laar A. Metabolic syndrome in apparently "healthy" Ghanaian adults: a systematic review and meta-analysis. *Int J Chronic Dis* 2017;2017:1–9.
23 Dabou S, Telefo PB, Fonkeng Sama L. Evaluation of dietary habits and lifestyle on the prevalence of metabolic syndrome and obesity in undergraduate university students in Cameroon: a cross sectional study. *J Metab Syndr* 2018;07:e236.
24 Kaduka LU, Kombe Y, Kenya E, *et al*. Prevalence of metabolic syndrome among an urban population in Kenya. *Diabetes Care* 2012;35:887–93.
25 Njelekela MA, Mpembeni R, Muhihi A, *et al*. Gender-Related differences in the prevalence of cardiovascular disease risk factors and their correlates in urban Tanzania. *BMC Cardiovasc Disord* 2009;9:e30.
26 Aguilar M, Bhuket T, Torres S, *et al*. Prevalence of the metabolic syndrome in the United States, 2003-2012. *JAMA* 2015;313:1973–4.
27 Shin D, Kongpakpaisarn K, Bohra C. Trends in the prevalence of metabolic syndrome and its components in the United States 2007–2014. *Int J Cardiol* 2018;259:216–9.
28 Atun R, Davies JI, Gale EAM, *et al*. Diabetes in sub-Saharan Africa: from clinical care to health policy. *Lancet Diabetes Endocrinol* 2017;5:622–67.
29 Olamoyegun M, Oluyombo R, Asaolu S. Evaluation of dyslipidemia, lipid ratios, and atherogenic index as cardiovascular risk factors among semi-urban dwellers in Nigeria. *Ann Afr Med* 2016;15:194–9.
30 Després J-P. Body fat distribution and risk of cardiovascular disease: an update. *Circulation* 2012;126:1301–13.
31 Sodjinou R, Agueh V, Fayomi B, *et al*. Obesity and cardio-metabolic risk factors in urban adults of Benin: relationship with socio-economic status, urbanisation, and lifestyle patterns. *BMC Public Health* 2008;8:e84.
32 Munyogwa MJ, Mtumwa AH. The prevalence of abdominal obesity and its correlates among the adults in Dodoma region, Tanzania: a community-based cross-sectional study. *Adv Med* 2018;2018:1–8.
33 Ekoru K, Murphy GAV, Young EH, *et al*. Deriving an optimal threshold of waist circumference for detecting cardiometabolic risk in sub-Saharan Africa. *Int J Obes* 2018;42:487–94.
34 Kavishe B, Biraro S, Baisley K, *et al*. High prevalence of hypertension and of risk factors for non-communicable diseases (NCDS): a population based cross-sectional survey of NCDS and HIV infection in northwestern Tanzania and southern Uganda. *BMC Med* 2015;13:126.
35 Bauer UE, Briss PA, Goodman RA, *et al*. Prevention of chronic disease in the 21st century: elimination of the leading preventable causes of premature death and disability in the USA. *Lancet* 2014;384:45–52.
36 Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health* 2009;6:790–804.
37 Sreeramareddy CT, Pradhan PM, Sin S. Prevalence, distribution, and social determinants of tobacco use in 30 sub-Saharan African countries. *BMC Med* 2014;12:243.
38 Virdis A, Giannarelli C, Neves MF, *et al*. Cigarette smoking and hypertension. *Curr Pharm Des* 2010;16:2518–25.
39 Kanter R, Caballero B. Global gender disparities in obesity: a review. *Adv Nutr* 2012;3:491–8.
40 Wilcox G. Insulin and insulin resistance. *Clin Biochem Rev* 2005;26:19–39.
41 Wesonga R, Guwatudde D, Bahendeka SK, *et al*. Burden of cumulative risk factors associated with non-communicable diseases among adults in Uganda: evidence from a national baseline survey. *Int J Equity Health* 2016;15:e195.
42 Mfutso-Bengo J, Masiye F, Molyneux M, *et al*. Why do people refuse to take part in biomedical research studies? Evidence from a resource-poor area. *Mal Med J* 2008;20:57–63.