

Hyperuricemia and Its Associated Factors Among Adult Staff Members of the Ethiopian Public Health Institute, Ethiopia

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Background: Hyperuricemia is related not only to an increased risk of gouty arthritis but also to an increased risk of cardiovascular diseases, resistant hypertension, insulin resistance and progression of type 2 diabetes mellitus. However, to the best of our knowledge, the prevalence of hyperuricemia and its associated factors have rarely been assessed in Ethiopian populations. Therefore, this study aimed to determine the prevalence of hyperuricemia and its associated factors among adult staff members of the Ethiopian Public Health Institute.

Methods: An institution-based cross-sectional study was conducted from July 1 to October 28, 2018. A total of 402 study participants were selected using a simple random sampling technique. An interviewer-administered questionnaire was used to collect the data. A blood sample of approximately 5 mL was collected from each study participant after overnight fasting through standardized methods for biochemical tests, and analyses were carried out with an automated COBAS 6000 analyzer. Data analysis was performed by SPSS version 20 software. The factors associated with the outcome variable were identified by bivariable and multivariable logistic regression analyses, and a p value <0.05 was used to declare statistical significance.

Results: The mean age of the study participants was 37.13 ± 10.5 (mean \pm SD), and 51.5% of the participants were male. The overall prevalence of hyperuricemia (>5.7 mg/dL for females and >7 mg/dL for males) was found to be 31.0%. The multivariable logistic analysis revealed that age (AOR=1.59, 95% CI 1.01–2.78), sex (AOR=1.66, 95% CI 1.02–2.70), cigarette smoking (AOR=2.05, 95% CI 1.01–4.19) and serum low-density lipoprotein (LDL) (AOR=1.70, 95% CI 1.01–2.87) were significantly associated with hyperuricemia.

Conclusion: The prevalence of hyperuricemia was relatively high compared to similar studies. Early screening for hyperuricemia in the general population, especially in those who are smokers, of older age and with high serum LDL levels, is vital to control its adverse effects at an early stage.

Keywords: adults, associated factors, uric acid, hyperuricemia

Introduction

Hyperuricemia is the state of having an abnormally elevated serum uric acid level. Under normal metabolic processes, uric acid is the end product of purine degradation and metabolism. The final two steps in purine metabolism comprise its catalysis by xanthine oxidoreductase, which converts hypoxanthine to xanthine, and then to uric acid.¹ At physiological pH, uric acid or its monoanion, urate, is considered to be without any physiological value and is excreted via urination.² However, owing to different factors, which could be genetic or acquired, purine metabolism can be disrupted and result in an abnormal increase in serum uric acid

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level (hyperuricemia).^{3,4} Clinically, knowing the prevalence of hyperuricemia is becoming an important concern for physicians owing to its strong association with gout and metabolic syndrome (MS). Besides, hyperuricemia may not be symptomatic until the late stages, and may be diagnosed after complications such as uremia and gout.⁵ In support of this, a 5-year follow-up study reported that 18.8% of asymptomatic hyperuricemic patients progressed into gout.⁶ The reason for this progression is that a high level of uric acid in the circulation results in an accumulation of monosodium urate crystals in peripheral joints and soft tissues, which, in turn, leads to the development of gout.⁷ Therefore, hyperuricemia may be taken as an independent risk factor for the development of gout; however, a study showed that only half of hyperuricemic patients could have the potential to develop gout.⁸ About 1–2% of the world's population are affected by gout, which is one of the most common chronic musculoskeletal diseases.⁹

Moreover, several studies have reported that there is a strong association between hyperuricemia and the incidence and progression of MS, chronic kidney disease and cardiovascular diseases (CVDs).^{10–19} Even in healthy populations, there is a strong association between elevated serum uric acid level and MS. Previous studies also revealed that if hyperuricemia has progressed to gout, the chance of developing MS is very high.^{20,21} Although the pathological role of elevated uric acid on MS is not completely understood, controlling the level of blood uric acid acts as a focal issue for high-risk asymptomatic individuals in the prediction of MS.^{22,23} Hyperuricemia is also positively associated with the incidence of insulin resistance and progression of type 2 diabetes mellitus.^{23–25} One study, conducted on elderly participants, stated that undiagnosed hyperuricemia is a strong risk factor for resistant hypertension (>140/90 mmHg) despite appropriate therapeutic approach and lifestyle modification.⁵ In addition, other research indicated that the chance of developing coronary or cerebrovascular disease associated with hypertension was three- to five-fold higher in hypertensive patients with hyperuricemia compared to non-hyperuricemic hypertensive patients.²⁶

Globally, the prevalence and incidence rate of hyperuricemia have steadily increased over time.²⁷ In 2004, the global prevalence of hyperuricemia was 5–30% across different populations.²⁸ More recent figures on the global prevalence of hyperuricemia and its associated factors do not appear to be available, but several lines of national and

regional data have been reported regarding this issue. The prevalence of hyperuricemia differs across different nations. For example, the age-standardized prevalence of hyperuricemia is 11.4% in the general population of the Republic of Korea,²⁹ 10.6% in a Thai population,³⁰ 12.1% in urban Izmir, Turkey,³¹ 24.4% in a Bangkok population,³² 13.7% in healthy adults in northern and northeastern China,³³ 25% in middle-aged, urban Chinese men³⁴ and 24% in the sub-Himalayan region in north India.³⁵ The incidence and prevalence of MS and gout have become major public health problems around the globe; however, their underlying causes, such as hyperuricemia, have not been clearly addressed. Furthermore, in developing countries, especially in sub-Saharan Africa, the prevalence of hyperuricemia and its associated factors have been infrequently studied. To the best of our knowledge, in Ethiopia, there has been only a limited number of studies on this issue. Therefore, this study aimed to determine the prevalence of hyperuricemia and its associated factors among adult staff members of the Ethiopian Public Health Institute (EPHI), Ethiopia. We hope that the findings of the study will provide input for clinicians as well as researchers. Furthermore, they may be useful for interventional plans to reduce metabolic disorders associated with hyperuricemia.

Methods

Study Setting and Design

An institution-based cross-sectional study was conducted from July 1 to October 28, 2018 among EPHI staff members. The study was conducted at the Ethiopian Public Health Institute (EPHI), which is located in Addis Ababa, the capital city of Ethiopia. The EPHI has been a well-known research institute in the country since 1995.

Study Participants and Sample Size Determination

The source population of the study was all adult staff members of the EPHI who had worked for a duration of >6 months, while staff members aged >18 years and who were present in the institution during the data collection period were taken as the study population. Of these, pregnant women and mothers in the postpartum period, sick individuals and individuals who were taking medications with known effects on purine metabolism, such as allopurinol, adenine, D-ribose and uridine, were excluded from the study.

A single population proportion formula was used to calculate the sample size of the study, $n = Z^2 p (1 - p)/d^2$, where Z is the Z score at 95% confidence interval = 1.96; p , prevalence = 50% (0.5); and d , marginal error = 5% (0.05). Thus, $n = (1.96)^2 0.5 (1 - 0.5)/(0.05)^2 = 384$. Considering a 5% non-response rate, the final total sample size of the study was 402. Study participants were selected using a simple random sampling technique.

Data Collection Procedure

The data were collected using a pretested interviewer-administered questionnaire. The questionnaires were prepared based on related literature in an international language (English), then translated into the local language (Amharic) to simplify the data collection and translated back to English to check their consistency. The questionnaire covered socio-demographic characteristics (sex, age, marital status and educational status), behavioral characteristics such as alcohol drinking, cigarette smoking, chat chewing and physical activity status, and clinical data, including a medically confirmed history of CVDs, hypertension, diabetes mellitus and kidney stone. The parts of the questionnaire designed to assess alcohol drinking, cigarette smoking and chat chewing status, as well as medically confirmed self-reported history of CVDs, hypertension, diabetes mellitus and kidney stone, were prepared with yes or no questions. Moreover, the participants were asked about the type, duration and frequency of alcohol drinking, cigarette smoking and chat chewing activities. Finally, alcohol drinking was defined as the intake of any type of alcohol beverage, such as beer, wine or locally prepared alcoholic beverages, more than once per week in the past year, regardless of the amount, whereas those who drank less than once per week in the past year or never drink alcoholic products were taken as non-drinkers.³⁶ Smokers were defined as those who practiced smoking cigarettes during the past year, regardless of the amount, while those who had never smoked in their lifetime or who had been smokers prior to the last year were taken as non-smokers. Chat chewers were defined in a similar way to smokers.³⁷

Physical activity was assessed according to World Health Organization (WHO) steps, by which any movement of the body produced by skeletal muscle, which requires energy expenditure, was taken as physical activity. Thus, physical activity was categorized into three levels: vigorous, moderate and inadequate or poor physical activity. A vigorous-intensity activity was defined as any activity that causes a large increase in breathing or heart rate (eg, running, carrying or lifting heavy loads, digging or construction work) that continues for at least

30 minutes for a minimum of three days per week. Moderate-intensity activity was defined as any activity that causes a small increase in breathing or heart rate (brisk walking or carrying light loads) that continues for at least 30 minutes for at least 3 days per week, or 5 or more days of these activities for at least 20 minutes per day or ≥ 3 days of vigorous-intensity activity per week for at least 20 minutes per day. Low-level (sedentary) physical activity was defined as an individual having physical activity that does not meet any of these criteria.³⁸

Anthropometric Measurements,

Physical parameters such as height, weight and blood pressure were measured using the WHO recommended standards.³⁸ The weight of each participant was measured in kilograms wearing light clothes and no shoes, and height was measured in centimeters using a height board, without shoes and in an upright position. Accordingly, body mass index (BMI) was calculated as the weight in kilograms divided by height in meters squared (m^2). Then, overweight was defined as a BMI between 24.9 and 30 kg/m^2 , and BMI ≥ 30 kg/m^2 was taken as obesity.³⁹ Blood pressure was measured after a minimum rest of 5 minutes, or 30 minutes for those who had drunk hot drinks such as coffee, with a sphygmomanometer at the midpoint of the left arm. The blood pressure was measured twice with an interval of 5 minutes, and the average value was taken as the true value. Then, hypertension was defined as a systolic/diastolic blood pressure $\geq 140/90$ mmHg or current use of anti-hypertensive drugs or a medically confirmed self-reported history of hypertension.⁴⁰ Diabetes mellitus was defined based on WHO guidelines, fasting blood sugar ≥ 126 mg/dL, a medically confirmed self-reported history of diabetes or current use of antidiabetic drugs.³⁸

Blood Sample Collection Procedure and Biochemical Analysis

A 5 mL blood sample was collected aseptically from each study participant after overnight fasting using a serum separator tube (SST). Blood samples were collected using an aseptic/sterile technique. The blood samples were allowed to clot in the tube at room temperature for 30 minutes, and then were centrifuged at 3000 rpm for 7 minutes using a Rotanta 960 centrifuge in thermostable conditions. Separated serum was transferred to sterile 1.5 mL Nunc tubes labeled with the study code, and kept frozen at $-20^\circ C$ until being transported to the National References Laboratory for Clinical Chemistry, EPHI, for laboratory analysis. Biochemical parameters, such as serum uric acid level, fasting blood glucose and lipid profile tests,

were analyzed by an automated COBAS 6000 analyzer. The cut-off points of the biochemical tests were taken according to the reference cut-off points of the COBAS 6000 analyzer. For instance, the outcome of the study (hyperuricemia) was diagnosed based on the reference cut-off point of the COBAS 6000 analyzer, which is >5.7 mg/dL for females and >7 mg/dL for males, and values below these cut-off points were taken as normal serum uric acid levels for the respective sexes.⁴¹

Quality Assurance

To achieve quality, training was provided for data collectors and supervisors. The training session included the objective of the study, data collection process, laboratory analysis and ethical issues. To evaluate the general approachability and feasibility of the questionnaires, a pretest was carried out using 10% of the sample size at St. Paul's Hospital Millennium Medical College before running the actual data. The overall quality of laboratory analysis was maintained by strictly following the manufacturers' instructions and standard operational procedure (SOP) in the preanalytic, analytic and postanalytic stages of laboratory services. The supervisors and investigators were strictly monitored data and sample collectors. To catch any errors, the collected data were double-checked for completeness, consistency, accuracy and clarity on a daily basis.

Statistical Analysis

Data analysis was performed using SPSS version 20 software. Descriptive data analysis was conducted and results were presented as frequency and percentage. Both binary and multivariable logistic regression analyses were performed to identify factors associated with hyperuricemia. Variables in the bivariable analysis with $p < 0.2$ were candidates for the final analysis in the multivariable logistic regression model. In multivariable logistic regression, variables with $p < 0.05$ were declared statistically significant. The Hosmer and Lemeshow goodness-of-fit test was performed.

Results

Socio-Demographic and Behavioral Characteristics of the Study Participants

In total, 402 study participants were enrolled. Of these, 400 participants completed the study. Just over half, 206 (51.5%), of the participants were male. The majority, 316 (79%), of the participants were aged 45 years or younger; thus, the mean \pm SD age of the participants was 37.13 ± 10.49 years. Most of the participants, 241 (60.3%) and

268 (67.0%), were married and educated up to college level and above, respectively. Regarding the behavioral status of the participants, 39 (9.8%), 266 (66.5%) and 63 (15.6%) were cigarette smokers, alcohol consumers and chat chewers, respectively. Besides, 119 (29.8%) of the participants performed vigorous physical activity and the majority, 260 (65%), of the participants were categorized as taking part in moderately intense physical activities (Table 1).

Clinical and Biochemical Characteristics of the Participants

Of the total participants, 122 (31.8%) and 32 (8.3%) were overweight and obese, respectively. Moreover, 72 (18%) and 13 (3.3%) of the participants had hypertension and diabetes mellitus, respectively, whereas 26 (6.5%) and 22 (5.5%) of the

Table 1 Socio-Demographic and Behavioral Characteristics of the Study Participants, Addis Ababa, Ethiopia, 2018 (n=400)

Variable	Number	Percent (%)
Sex		
Female	194	48.5
Male	206	51.5
Age (mean \pm SD)	37.13 \pm 10.49	
≤ 45 years	316	79.0
> 45 years	84	21.0
Marital status		
Never married	132	33.0
Married	241	60.3
Separated/widowed/divorced	27	6.8
Educational status		
Primary school and less	64	16.0
Secondary school education	68	17.0
College and above	268	67.0
Smoking status		
Non-smoker	361	90.3
Smoker	39	9.8
Alcohol drinking status		
Non-drinker	134	33.5
Drinker	266	66.5
Chat chewing status		
Non-chewer	337	84.3
Chewer	63	15.8
Physical activity status		
Vigorous	119	29.8
Moderate	260	65.0
Inadequate	21	5.3

participants had clinically confirmed self-reported history of kidney stone and CVDs, respectively. Concerning the biochemical analysis, 84 (21%), 116 (29%) and 103 (25.8%) of the participants had abnormal elevations of serum triglyceride, cholesterol and low-density lipoprotein (LDL), respectively. Besides, a significant number of the participants, 162 (40.5%), had a low level of serum HDL. The mean \pm SD values of estimated glomerular filtration rate (eGFR) according to the Modification of Diet in Renal Disease (MDRD) and Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equations were 132.47 ± 27.42 mL/min/1.73 m² and 130.99 ± 23.24 mL/min/1.73 m², respectively. None of the study participants was defined as having chronic kidney disease (eGFR <60 mL/min/1.73 m²), regardless of the equations used (Table 2).

Prevalence of Hyperuricemia Among the Participants

A total of 124 hyperuricemia cases with an overall prevalence of 31% (95% CI 26.5–35.8) was found in the present study. Of these, about 78 (62.9%) of male participants and 46 (37.1%) of female participants were found to be hyperuricemic. The mean \pm SD uric acid level of the study participants was 5.93 ± 2.31 mg/dL (Table 2).

Factors Associated With Hyperuricemia

The multivariable logistic regression analysis revealed that sex, age, cigarette smoking status and serum LDL level were significantly associated with hyperuricemia. The odds of having hyperuricemia were 1.66 times (AOR=1.66, 95% CI 1.02–2.70) higher among male participants than females. The probability of having hyperuricemia was 1.59 times (AOR=1.59, 95% CI 1.01–2.78) higher in elderly respondents than in younger participants. The odds of having hyperuricemia were 2.05 times (AOR=2.05, 95% CI 1.01–4.19) higher in cigarette smokers than non-smokers. The odds of having hyperuricemia were 1.70 times (AOR=1.70, 95% CI 1.01–2.87) higher in participants who had high serum LDL levels than in those who had normal serum LDL levels (Table 3).

Discussion

This study assessed the hidden burden of hyperuricemia and its associated factors among adult staff members of the EPHI, Ethiopia.

The prevalence of hyperuricemia was found to be 31% (95% CI 26.5–35.8). This figure is in line with studies

Table 2 Clinical and Biochemical Characteristics of the Study Participants, Addis Ababa, Ethiopia, 2018 (n=400)

Variables	Mean \pm SD	Number	Percent (%)
BMI (kg/m ²)	24.62 \pm 7.53		
<25		232	58.0
25–29.9		129	32.3
\geq 30		39	9.8
Blood pressure (mmHg)	122.72/81.59 \pm 19.35/11.64		
Hypertension			
No		328	82.0
Yes		72	18.0
Fasting blood glucose	85.57 \pm 14.90		
Diabetes mellitus			
No		387	96.8
Yes		13	3.3
History of kidney stone			
No		374	93.5
Yes		26	6.5
History of CVD			
No		378	94.5
Yes		22	5.5
Triglyceride (mg/dL)	115.16 \pm 59.35		
Normal		316	79.0
High		84	21.0
Cholesterol (mg/dL)	179.34 \pm 38.80		
Normal		284	71.0
High		116	29.0
LDL (mg/dL)	107.38 \pm 33.21		
Normal		297	74.3
High		103	25.8
HDL (mg/dL)	48.94 \pm 12.92		
Normal		238	59.5
Low		162	40.5
Dyslipidemia			
Normal		203	50.8
Dyslipidemic		197	49.3
eGFR with MDRD equation (mL/min/1.73 m ²)	132.47 \pm 27.42		
eGFR with CKD-EPI equation (mL/min/1.73 m ²)	130.99 \pm 23.24		
Uric acid level (mg/dL)	5.93 \pm 2.31		
Normal		276	69.0
Hyperuricemia		124	31.0

Note: Normal cholesterol <200 mg/dL, high cholesterol \geq 200 mg/dL, normal triglyceride <150 mg/dL, high triglyceride \geq 150 mg/dL, normal LDL <100 mg/dL, high LDL \geq 100 mg/dL, low HDL \leq 40 mg/dL for males and \leq 50 mg/dL for females, hyperuricemia >5.7 mg/dL for females and >7 mg/dL for males.

Abbreviations: BMI, body mass index; CVD, cardiovascular disease; LDL, low-density cholesterol; HDL, high-density cholesterol; eGFR, estimated glomerular filtration rate; MDRD, Modification of Diet in Renal Disease; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration.

Table 3 Factors Associated With Hyperuricemia in the Study Participants, Addis Ababa, Ethiopia, 2018 (n=400)

Covariates	Normal Uric Acid Level, n=276	Hyperuricemia, n=124		
	N (%)	N (%)	COR (95% CI)	AOR (95% CI)
Sex				
Female	148 (76.3)	46 (23.7)	1	
Male	128 (62.1)	78 (37.9)	1.96 (1.27–3.03)	1.66 (1.02–2.70)*
Age (years)				
≤45	229 (72.5)	87 (27.5)	1	
>45	47 (56.0)	37 (44.0)	2.07 (1.26–3.40)	1.59 (1.01–2.78)*
Smoking status				
Non-smoker	258 (71.5)	103 (28.5)	1	
Smoker	18 (46.2)	21 (53.8)	2.92 (1.49–5.71)	2.05 (1.01–4.19)*
Alcohol drinking status				
Non-drinker	99 (73.9)	35 (26.1)	1	
Drinker	177 (66.5)	89 (33.5)	1.42 (0.90–2.26)	1.23 (0.75–2.02)
Chat chewing status				
Non-chewer	239 (70.9)	98 (29.1)	1	
Chewer	37 (58.7)	26 (41.3)	1.76 (1.01–3.07)	0.88 (0.42–1.85)
BMI (kg/m ²)				
<25	170 (71.1)	69 (28.9)	1	–
≥25	106 (65.8)	55 (34.2)	1.28 (0.83–1.96)	
Hypertension				
No	235 (71.6)	93 (28.4)	1	
Yes	41 (56.9)	31 (43.1)	1.91 (1.13–3.23)	1.52 (0.84–2.76)
Diabetes mellitus				
No	269 (69.5)	118 (30.5)	1	
Yes	7 (53.8)	6 (46.2)	1.95 (0.64–5.94)	–
History of kidney stone				
No	257 (68.7)	117 (31.3)	1	
Yes	19 (73.1)	7 (26.9)	0.81 (0.33–1.98)	–
History of CVD				
No	264 (69.8)	114 (30.2)	1	
Yes	12 (54.5)	10 (45.5)	1.93 (0.81–4.60)	1.60 (0.64–4.01)
Physical activity status				
Vigorous	80 (67.2)	39 (32.8)	1	—
Moderate	178 (68.5)	82 (31.5)	0.95 (0.59–1.50)	
Inadequate	18 (85.7)	3 (14.3)	0.34 (0.095–1.23)	
Triglyceride				
Normal	213 (67.4)	103 (32.6)	1	
High	63 (75.0)	21 (25.0)	0.69 (0.40–1.19)	0.55 (0.30–1.04)
Cholesterol				
Normal	196 (69.0)	88 (31.0)	1	—
High	80 (69.0)	36 (31.0)	1.00 (0.63–1.6)	
LDL				
Normal	211 (71.0)	86 (29.0)	1	
High	65 (63.1)	38 (36.9)	1.43 (0.89–2.30)	1.70 (1.01–2.87)*

(Continued)

Table 3 (Continued).

Covariates	Normal Uric Acid Level, n=276	Hyperuricemia, n=124		
	N (%)	N (%)	COR (95% CI)	AOR (95% CI)
HDL				
Normal	166 (69.7)	72 (30.3)	1 1.09 (0.71–1.68)	—
Low	110 (67.9)	52 (32.1)		
Dyslipidemia				
Normal	138 (68.0)	65 (32.0)	1 0.91 (0.59–1.39)	—
Dyslipidemic	138 (70.1)	59 (29.9)		

Note: *Statistically significant at $p < 0.05$.

Abbreviations: BMI, body mass index; CVD, cardiovascular disease; LDL, low-density lipoprotein; HDL, high-density lipoprotein; COR, crude odds ratio; AOR, adjusted odds ratio.

conducted in western China (27.9%)⁴² and Taiwan (30.6%)⁴³ and in males of developing countries (35.2%).⁷ On the other hand, the finding of our study is lower than in a study on South Indian adult patients with stable coronary artery disease (46.5%).⁴⁴ However, the prevalence of hyperuricemia in this study is higher than in studies conducted with Black Africans (25%),⁴⁵ in a rural northeast Chinese population (10.9%),⁴⁶ in middle-aged, urban Chinese men (25%),³⁴ and in populations from the sub-Himalayan region in North India (24%),⁴⁷ Republic of Korea (11.4%),²⁹ Italy (6.3%)⁴⁸ and Eastern Europe (25%).⁴⁹ These discrepancies may be due to differences in ethnic background and study populations. The discrepancies may also be due to differences in study settings, as the current study was conducted only among EPHI staff members who worked in a sitting position for a prolonged time; this may increase the prevalence of hyperuricemia because individuals who spend a prolonged time sitting at work are at high risk of acquiring the risk factors of chronic diseases, such as sedentary lifestyle.⁵⁰ Thus, in turn, increases the chance of developing metabolic disorders, including abnormal elevation of serum uric acid levels.^{46,51} Variations in the findings could also be due to dietary variation, endogenous synthesis and degradation ratio, or purine metabolism of the study participants.⁵²

In the current study, sex, age, cigarette smoking and serum LDL level were found to be significantly associated with hyperuricemia. Accordingly, male participants were 1.66 times more likely to have hyperuricemia compared with female individuals. This finding is consistent with studies conducted in Nigeria,⁵³ China⁵⁴ and India,⁵⁵ which revealed that males have a higher risk of hyperuricemia. The higher likelihood of hyperuricemia in males than females may be due to the action of sex hormones, in

that the female sex hormone estrogen helps in the excretion of uric acid and could have the ability to maintain blood uric acid levels.^{56,57} Besides, the risk of exposure to environmental and dietary factors that aid the synthesis of purine is higher in males than females, which may also contribute to the production of more uric acid owing to regulatory activity of purine metabolism, which further results in the release of high levels of uric acid into the circulation.^{58,59} In addition, males may also be more likely to take part in alcohol drinking activities compared to females, and alcoholic products have the ability to activate the expression of ATP binding cassette transporter sub-family G member 2 (ABCG2). The activation of ABCG2 stimulates the reabsorption of urate in the renal ductal tube, which, in turn, results in an increased serum uric acid level.^{60,61}

In this study, the odds of having hyperuricemia were 1.59 times higher among participants who were aged >45 years than in younger participants. In line with the current study, hyperuricemia was found to be significantly associated with older age in studies conducted on female participants in a rural northeast Chinese population⁴⁶ and in a Taiwanese population.⁶² A possible reason for the increased odds of hyperuricemia in older age may be due to changes in renal function and body composition. After the age of 40, kidney function decreases by 10% for every 10-year increase in age, leading to impaired excretion of uric acid, which may, in turn, result in the accumulation of uric acid in the blood.⁶³ Furthermore, during aging, predisposing factors for hyperuricemia and crystal deposition, such as aging of joints, osteoarthritis and prolonged overloading of joints due to being overweight, become more prevalent. Therefore, the burden of having hyperuricemia may be increased.⁶⁴

In the present study, the odds of having hyperuricemia among cigarette smokers were 2.05 times higher than for non-cigarette-smoking participants, which is supported by other, similar studies.^{65–67} One possible explanation for the increase in serum uric acid levels following cigarette smoking could be the deleterious effects of smoking on renal function and structure due to the production of reactive oxygen species. The toxic effect of cigarette smoking on renal cells can lead to the reduction of renal function and structural impairment, which further results in a decrease in uric acid excretion and an increase in serum uric acid level.^{68,69} The protective role of uric acid against oxidative molecules may be another possible reason, because cigarette smoking generates oxidative molecules such as reactive oxygen species in the body, and to overcome the metabolic stress more uric acid will be produced.¹ Uric acid is the most abundant aqueous antioxidant, accounting for up to 60% of serum free radical scavenging capacity, and it is an important intracellular free radical scavenger during metabolic stress, including cigarette smoking.^{70,71} Antioxidants are believed to play an important role in resisting oxidative damage, by scavenging the oxidants resulting from free radicals in the cigarette or produced in the body as a result of ingredients in the cigarette.⁷² Therefore, the compensatory overproduction of uric acid may have contributed to the increased uric acid level.

Furthermore, the probability of having hyperuricemia was 1.70 times higher in participants with high serum LDL levels than in those who had normal serum LDL levels. This is consistent with the findings of previous studies conducted in different regions of the world.^{73–76} The possible reason for the high chance of hyperuricemia among participants with higher serum LDL levels than normal may be due to the coincidence of common risk factors such as cigarette smoking, unhealthy diet and environmental factors.⁷⁷ Besides, the disturbances to metabolic processes in individuals with a high level of serum LDL may also have contributed to the production of high levels of uric acid. Even though the mechanisms linking dyslipidemia and hyperuricemia are not fully understood, it is hypothetically proposed that the synthesis of triglycerides and cholesterol will need NADPH as a reducing molecule for the fatty acid synthase complex and HMG-CoA reductase enzyme, respectively, which may result in an increase in uric acid production secondary to the up-regulation of the pentose phosphate pathway.⁷⁸ In conclusion, we found that hyperuricemia was highly prevalent and statistically

associated with older age, male sex, cigarette smoking and high serum LDL levels. Therefore, early screening to detect hyperuricemia could have advantages for the general population, to overcome the complications of hyperuricemia and to control it at an early stage.

Limitations

The main limitation of this study was its inability to assess the dietary habits of the participants, which are believed to be one of the factors associated with hyperuricemia. We were also unable to display participants on antihypertensive therapy in the multivariate model analysis. The number of participants was also relatively small.

Abbreviations

CVD, cardiovascular disease; MS, metabolic syndrome; BMI, body mass index; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

Data Sharing Statement

All data and material are available within the manuscript.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Addis Ababa University, Biochemistry Department Ethics and Research Committee (DRERC) (protocol number M.Sc. 09/18, meeting number DRERC 08/18). Written informed consent was obtained from each study participant before running the study. Participants were informed that they had the full right to withdraw from the study at any time without justifying their reason. The results of the study participants were kept confidentially.

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the

version to be published; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest for this work.

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