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Association between total cholesterol to HDL-cholesterol ratio and Probable dementia among older people: A cross-sectional study in Southwestern Uganda

Dianah Ishimwe [a,1], Charles Nkubi Bagenda [a,*,1], Ruth Tushemerirwe [a], Jacinta Namugangu [a], Rogers Mungufeni [a], Patrick Unzima [a], Elastus Ssemwanga [g], Carol Nantongo [a], Michael Junior Mugisa [a], Hope Mudondo [a], Lucas Ampaire [a], Enoch Muwanguzi [a], Catherine Abaasa [a], Samuel Ojuko [e], Fred Sempijja [c], Amos Oyuru [d], Benson Musinguzi [f], Winnie Akiteng [f], Lawrence Obado Osuwat [e], Simon Peter Rugera [a], Deusdedit Tusubira [b]

[a] Department of Medical Laboratory Science, Faculty of Medicine, Mbarara University of Science and Technology, P.O. Box 1410, Mbarara City, Uganda
[b] Department of Biochemistry, Faculty of Medicine, Mbarara University of Science and Technology, P.O. Box 1410, Mbarara City, Uganda
[c] Uganda Institute of Allied Health and Management Sciences, P.O. Box, 34025, Kampala, Uganda
[d] Department of Pharmacy, Faculty of Medicine, Mbarara University of Science and Technology, P.O. Box 1410, Mbarara City, Uganda
[e] Department of Medical Laboratory Science, School of Health Sciences, Soroti University, P.O. Box 211, Soroti City, Uganda
[f] Department of Medical Laboratory Science, Faculty of Health Science, Muni University, P.O. Box 725, Arua City, Uganda
[g] Department of Medical Laboratory Technology, Mayanja Memorial Medical Training Institute, P.O Box 348, Mbarara, Uganda

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ABSTRACT

Background: Dementia is a condition characterized by a decline in cognitive abilities that exceeds what could normally be anticipated due to the natural process of ageing. This study assessed the association of serum lipoproteins with probable dementia among older people in Rukiga District, South-western Uganda.
Methods: This was a community-based cross-sectional study in Rukiga District, South-western Uganda. The study was conducted from February 15, 2025 to March, 29, 2025 among 272 individuals 60 years of age and above who were selected through multistage sampling. Data were collected using a researcher-administered questionnaire supplemented with information from participant's medical records and a brief community screening instrument for dementia. Anthropometric measurements were taken and a blood sample was drawn for laboratory measurement of serum lipoproteins.
Results: Of 272 participants, 45 (16.5%) had probable dementia. Participants with probable dementia had significantly higher total cholesterol levels (median: 172 mg/dL, IQR: 140–199) compared to those without probable dementia (156 mg/dL, IQR: 134–183, p=0.019). In multivariable analysis, total cholesterol to HDL-cholesterol (TC/HDL-C) (aOR: 1.13, 95% CI: 1.01–1.25, p=0.027), age;(aOR: 1.27, 95% CI: 1.16–1.39, p<0.001) and low physical activity; (aOR: 3.55, 95% CI: 1.04–12.08, p=0.042) ratio were significantly associated with probable dementia.
Conclusions: Probable dementia was relatively common among community-dwelling older adults in Southwestern Uganda. TC/HDL-C ratio, advancing age, and low physical activity levels are potentially associated with probable dementia. We recommend future studies incorporating standardized clinical diagnostic criteria for dementia to confirm these findings.

* Corresponding author.
E-mail address: cbagenda@must.ac.ug (C.N. Bagenda).
[1] These authors contributed equally to this work

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1. Introduction

Dementia is a condition that impairs thinking, behavior, and memory and makes it difficult to carry out daily tasks [1,2]. Among the aged population worldwide, it is one of the main causes of impairment and hospitalization [3]. Alzheimer's disease(AD); a degenerative brain illness is the most frequent cause of dementia, accounting for about 60-80% of all dementia cases [4]. Globally, an estimated 55 million people suffer from dementia [5], and by 2050, that number is expected to rise to 152.8 million [6]. More than two thirds of people living with Alzheimer's disease and related dementias (ADRD) reside in low- and mid-income countries [7]. The age adjusted dementia prevalence in Sub-Saharan Africa(SSA) is estimated at 7.2% among people aged 60 years and above [8]. The number of older people in Uganda is growing [9] and these need extra care to lessen the impact of dementia. Collaborators et al. (2021), as supported by Nichols et al. (2022), estimate that Alzheimer's disease and other dementias caused 1,286 deaths in Uganda in 2020, accounting for 0.62% of all deaths [6,10]. The age-adjusted mortality rate for Alzheimer's and other dementias was 19.36 per 100,000 population. Based on this rate, Uganda ranked 60th globally in terms of the dementia-related mortality burden [6,10]. In South-western Uganda which has the highest proportion of older people among all Ugandan subregions, the prevalence of dementia and related diseases among people 60 years of age and older is reported to be 20% [11]. which is about three times higher than the 7.2% prevalence in SSA [12].

Despite the growing older population in Uganda, standardized protocols for diagnosing dementia remain absent [13]. Investigating the correlation between dementia prevalence and blood-based biomarkers could provide a foundation for their potential use in identifying at-risk individuals and facilitating early intervention. Additionally, a biomarker-based approach to diagnosing dementia in the future would enhance the accuracy of dementia prevalence estimates in our region. Whereas, the determination of total tau, phosphorylated tau, and amyloid-β levels in cerebrospinal fluid are said to be the most extensively studied fluid biomarkers for dementia [14], there is a pressing need for novel, blood-based, less invasive, cost-effective, easily detectable, and more accessible biomarkers, particularly in resource-limited settings like southwestern Uganda. Prospective studies in specific populations have shown that abnormalities in circulating lipids serve as independent predictors of dementia development [15–21]. Elevated total cholesterol (TC) levels have been linked to an increased risk of AD [2,22–24], whereas higher high-density lipoprotein cholesterol (HDL-C) levels are associated with a reduced risk of AD [25]. Furthermore, a number of studies have shown that there exists a risk of dementia upsurge with a number of other modifiable risk factors such as smoking, alcohol consumption, unbalanced diets, lifestyle, depression, and diabetes, hypertension, midlife obesity, and physical inactivity [26–29].

Although dyslipidemia and alterations in lipoprotein profiles have been associated with cognitive impairment and dementia in other populations, findings have been inconsistent, and evidence among older adults in African settings remains scarce. Furthermore, lipid ratios, such as the total cholesterol-to-high-density lipoprotein cholesterol (TC/HDL-C) ratio, may reflect the balance between atherogenic and protective lipoproteins more comprehensively than individual lipid measures, but their relationship with probable dementia has been insufficiently characterized in in African settings. To the best of our knowledge, no study in Uganda has assessed the relationship between lipid biomarkers and probable dementia. Therefore, the main purpose of our study was to assess the association between lipoprotein biomarkers and probable dementia among older people in Southwestern Uganda. By characterizing these cross-sectional associations, the study sought to address an important evidence gap and generate hypotheses that can inform future longitudinal studies investigating the temporal and potential causal relationships between lipid profiles and cognitive decline in older African populations.

2. Methods

2.1. Study design, setting, population, eligibility criteria and sampling technique

We conducted a community-based descriptive and analytical cross-sectional study among people aged 60years and above in Rukiga district from February 15, 2025 to March, 29, 2025. Rukiga District is situated in the Kigezi region of Southwestern Uganda. Notably, Kigezi has the highest proportion of older adults (60 years and above) in Uganda, accounting for 6% of the country's older population, surpassing all other sub-regions [9]. Approximately 5% of the total population in this region is aged 60 years or older [9]. With a prevalence of 20% among individuals aged 60 and above, dementia is a significant public health concern in this region [11]. Adults aged ≥60 years who were residents of the selected communities in Rukiga District and provided informed consent were eligible for participation. Individuals who were unable to communicate verbally sufficiently to complete the study assessments were excluded. To ensure representativeness in village and participant selection, we employed the World Health Organization (WHO) cluster probability sampling method, a widely used approach for surveys and studies where individual-level sampling is impractical or unfeasible [30]. Older individuals were identified by the Village Health Teams (VHTs), which are the primary community-based health structures, also referred to as Health Center I in Uganda's health service delivery system. The VHTs, consisting of trained community health volunteers, maintain registers of all residents, including older persons, within their designated areas [31].

2.2. Sample size determination

We used the Kish and Leslie formula of 1965 [32] to determine the minimum required sample size using the following assumptions; 20% prevalence of Dementia in South-Western Uganda [11], 5% precision and a 95% confidence interval and the Z-statistic of 1.96.

$\mathbf{n = Z^2P\ (1\text{-}P)/d^2}$ where n is required sample size, Z is Z-statistic for a level of confidence, P is expected prevalence, and d is precision.

$$n = 1.96^2 x 0.2(1 - 0.2)/0.05^2 = 245.86$$

Taking 10% non-responsive rate into consideration i.e. 0.1 * 246 = 24.6

Therefore, the minimum sample size required = 246 + 25 = 271 older study participants. A design effect was not incorporated into the sample-size calculation despite the use of cluster sampling and this has been acknowledged as a methodological limitation.

2.3. Sampling procedure

Participants were recruited using a multistage cluster sampling approach, with villages serving as the primary sampling clusters. Rukiga District comprises four sub-counties and two town councils, subdivided into 30 parishes/wards and 293 villages. Villages were selected from the district sampling frame, after which VHTs in the selected villages assisted the research team in identifying residents aged ≥60 years from their community registers. Eligible older adults identified within the selected clusters constituted the participant sampling frame. Participants were subsequently selected from these lists and approached at household level, where eligibility was confirmed and written informed consent obtained before enrolment. The minimum required sample size was 271 participants after allowing for 10% nonresponse. Recruitment continued until the required sample size was attained, and 272 eligible consenting older adults were ultimately enrolled in the study. The numbers of individuals initially approached, found ineligible, declining participation, or unavailable were not captured in the final analytical dataset; consequently, an exact response rate could not be reliably

reconstructed retrospectively.

2.4. Study variables and data collection tools

2.4.1. Dependent variable

Probable dementia was the primary outcome variable. Screening was conducted using the Brief Community Screening Instrument for Dementia (CSID), a tool suitable for use by non-specialists in low-resource settings [33]. The CSID includes a cognitive assessment administered directly to the participant and an informant assessment administered to a caregiver or close relative. The cognitive component comprises seven items and yields a score ranging from 0 to 9, with higher scores indicating better cognitive performance. The informant component comprises six items and yields a score ranging from 0 to 6, with higher scores indicating greater reported impairment. For this study, probable dementia was operationally defined using the CSID cognitive score alone. Participants with a CSID cognitive score $\leq$4 were classified as having probable dementia, whereas those with a cognitive score >4 were classified as not having probable dementia [11,33].

2.4.2. Independent variables

Dyslipidemia, the abnormal levels of serum lipid parameters, were the major independent variables of this study. To determine the serum triglycerides (TG), total cholesterol (TC), High density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C), a blood sample was drawn from each of the participants using a red top vacutainer. Each participant fasted for 8 to 12 hours before sample collection.. The collected blood samples were transported from the field in the community in a dry ice-packed cool box to the testing laboratory at Mparo Health Centre IV, Rukiga District. The samples were immediately centrifuged to obtain serum which was used to measure the concentration of TG, TC, LDL- C, and HDL-C through enzymatic methods using the Huma Star 200 automated clinical chemistry analyzer. Quality control samples were run and passed before the patients' samples were run.

Dyslipidemia was defined based on the National Cholesterol Education Program Adult Treatment Panel III guideline as TG $\geq$150 mg/dL, TC$\geq$200 mg/dL, LDL-*C* $\geq$ 130 mg/dL, and HDL-*C* < 40 mg/dL for men, <50 mg/dL for women, occurring in isolation or combination [34]. The TC/ HDL-C ratio was calculated by dividing serum TC concentration (numerator) by the serum HDL-C concentration(denominator). The TC/ HDL-C ratio was considered as raised if it was $\geq$5 [34].

A structured Questionnaire composed of standard data collection tools was administered to collect data on the social-demographic factors, behavioral, and clinical factors. Physical activity was assessed using the International Physical Activity Questionnaires(IPAQ) [35] and categorized as <600(low) and $\geq$600 MET-minutes/Week(adequate) [36] Depression was assessed using Patient Health Questionnaire 9(PHQ 9) [37]. A non-stretchable Seca Ergonomic Circumference Measuring Tape was used to measure waist and hip circumferences. Two measurements were recorded, and if the difference between the first two exceeded 3 cm, a third measurement was taken to ensure accuracy. The final waist and hip circumferences were determined as the mean of the two or three recorded values. High waist circumference was defined as >80 cm for females and >94 cm for males [38]. Waist to hip ratio was calculated from waist and hip circumferences and considered to be high if $\geq$0.85 for females and $\geq$0.9 for males [38]. A digital sphygmomanometer was used to measure blood pressure. Two readings were taken at a 5-minute interval, and their mean was considered the final blood pressure value. Hypertension was defined as a systolic blood pressure of $\geq$140 mmHg and/or a diastolic blood pressure of $\geq$90 mmHg [39]. Mid-upper arm circumference (MUAC), used as an anthropometric indicator of nutritional status, was measured using a flexible, non-stretchable measuring tape. Low fruit and vegetable intake was defined as consuming less than five servings of fruit and vegetables per day [40]. The data of other independent variables, namely gender, education level, smoking status, alcohol consumption status, Vegetable and fruit intake, Number of days for vegetable and fruit intake, Dinner time, Sleep duration, Diabetes Mellitus, Hypertension, family history of dementia and chronic conditions (Diabetes Mellitus, Hypertension, cardiovascular diseases) was collected using the same structured questionnaire with some variables collected as continuous and others as categorical variables

2.5. Statistical analysis

The collected data was double entered into Microsoft excel which was exported to STATA version 17 Software for analysis. There were no missing observations for variables included in the analysis. Continuous variables were tested for normality using the Shapiro-wilk normality test and all were not normally distributed($p<0.05$) with the exception of LDL-C($p=0.11$). These were summarized using median (interquartile range: IQR) and a nonparametric test; Mann-Whitney U test was used to compare their medians between participants with and without the outcome variable (Probable dementia) to test if there are any statistical differences between the two groups. LDL-C was summarized using mean $\pm$SD and a student's t-test used for comparison of the means between the two groups of probable dementia. A P value <0.05 was considered statistically significant. Categorical variables were summarized using frequencies and proportions(percentages).

The proportions of study participants with probable dementia together with its 95% Confidence Intervals was determined by dividing the number of participants with probable dementia by the total number of study participants recruited and was expressed as percentage and graphically presented using a pie chart. The distribution of probable dementia prevalence across the different levels of each of the categorical independent variables was compared using a Chi square test or Fischer's exact test. A P value <0.05 will be considered to be statistically significant

The association of the lipid biomarkers and other independent variables with probable dementia was assessed using logistic regression. Probable dementia was a binary dependent variable (0=absent, 1=present). The association between each independent variable and probable dementia was initially assessed using bivariable logistic regression, and crude odds ratios (cORs) with 95% confidence intervals (CIs) were estimated. Variables with a bivariable p-value $\leq$0.20 and variables considered a priori clinically relevant potential confounders were considered for inclusion in the initial multivariable logistic regression model. The initial model included age, sex, education level, number of days of fruit and vegetable intake, dinner time, physical activity, depression (PHQ-9 category), diabetes mellitus, hypertension, waist circumference, waist-to-hip ratio, mid-upper arm circumference, total cholesterol, triglycerides, LDL-C, HDL-C, dyslipidemia, TC/HDL-C ratio, systolic blood pressure, and diastolic blood pressure.

Before fitting the final model, conceptually related variables were assessed for collinearity. Systolic and diastolic blood pressure were excluded because of collinearity with hypertension, while hypertension was retained as the corresponding clinical variable. Similarly, waist-to-hip ratio was excluded because of collinearity with waist circumference, while waist circumference was retained. Number of days of fruit and vegetable intake, dinner time, and mid-upper arm circumference were subsequently removed from the full model because their inclusion reduced the precision of the model estimates without significantly altering the estimated associations of the principal variables of interest.

The final multivariable model therefore included age, sex, education level, physical activity, depression (PHQ-9 category), diabetes mellitus, hypertension, waist circumference, total cholesterol, triglycerides, LDL-C, HDL-C, dyslipidemia, and TC/HDL-C ratio. All the covariates were entered simultaneously in the same model rather than evaluated in separate adjusted models. Multicollinearity in the final multivariable model was assessed using variance inflation factors (VIFs). The mean VIF was 1.52, with individual VIFs ranging from 1.16 to 2.03, below the prespecified threshold of 5. Although TC/HDL-C is mathematically

derived from TC and HDL-C and these measures were included simultaneously with LDL-C and dyslipidemia, the observed VIFs did not indicate severe multicollinearity in the fitted model. The regression analyses used conventional model-based standard errors and did not incorporate village-level clustering. The suitability of the final model in predicting the probable dementia was assessed using Hosmer–Lemeshow test and the p-value was 0.459 indicated good goodness of fit for the final model. Model goodness-of-fit was assessed using the Hosmer–Lemeshow test. The test yielded a p-value of 0.459, indicating no evidence of lack of fit and suggesting that the final model adequately fitted the observed data. Adjusted odds ratios (aORs) with 95% CIs were reported, and associations with a two-sided *p*-value ≤0.05 were considered statistically significant.

3. Results

3.1. Socio demographic characteristics of the study participants

The study included 272 participants with a median age of 67 years (IQR: 63–73). The majority were female 166(61.0%), married or cohabiting 233(85.7%), and Protestant 204(75.0%). Most participants were unemployed 186(68.4%) and had no formal education 141 (51.8%), while 99(36.4%) had primary education, and only 32(11.8%) attained secondary or tertiary education as indicated in Table 1.

3.2. Proportion of older participants with probable dementia

Out of the 272 participants, 45 has a SCID score ≤4, giving an overall probable dementia prevalence of 16.5%(95%CI: 12.8 - 21.5). The study findings revealed significant associations between probable dementia and several socio-demographic and clinical factors Table 2. Participants with probable dementia were significantly older, with a median age of 82 years (IQR: 76–89) compared to 65 years (IQR: 62–70) among those without dementia (p<0.001). Education level was also significantly associated with probable dementia (p<0.001), with a higher prevalence among individuals with no formal education (25.5%) compared to those with primary (7.1%) or secondary/tertiary education (6.3%). Physical activity levels showed a strong inverse association with probable dementia. Participants with probable dementia had a significantly lower median physical activity level of 396 MET-mins/week (IQR: 0–594), whereas those without probable dementia had a median of 2697 MET-mins/week (IQR: 1188–4464, p<0.001). Additionally, 51.5% of participants with physical activity levels below 600 MET-mins/week had probable dementia had compared to only 4.9% probable dementia prevalence among those physical activity levels ≥ 600 MET-mins/week (p<0.001). Depressive symptoms, as assessed by the PHQ-9 score, were

Table 1
Socio demographic characteristics of the study participants.

Variables	Total N=272
Age(years): Median (IQR)	67 (63-73)
Gender, n (%)	
Male	106 (39.0)
Female	166 (61.0)
Marital status, n (%)	
Married/cohabiting	233 (85.7)
Divorced/Separated	39 (14.3)
Religion, n (%)	
Catholic	68 (25.0)
Protestant	204 (75.0)
Employment, n (%)	
Unemployed	186 (68.4)
Employed	86 (31.6)
Education level, n (%)	
No education	141 (51.8)
Primary	99 (36.4)
Secondary/Tertiary	32 (11.8)

Table 2
Distribution of probable dementia prevalence across different categorical independent variables.

Variable	Total N=272	Probable dementia		p-value
		Absent N=227	Present N=45	
Age(years): Median (IQR)	67 (63-73)	65 (62-70)	82 (76-89)	**<0.001**
Gender, n (%)				0.13
Male	106 (39.0)	93 (87.7)	13 (12.3)	
Female	166 (61.0)	134 (80.7)	32 (19.3)	
Education level, n (%)				**<0.001**
No education	141 (51.8)	105 (74.5)	36 (25.5)	
Primary	99 (36.4)	92 (92.9)	7 (7.1)	
Secondary/Tertiary	32 (11.8)	30 (93.8)	2 (6.3)	
Smoking, n (%)				0.70
Never smoked	218 (80.1)	181 (83.0)	37 (17.0)	
Ever smoked	54 (19.9)	46 (85.2)	8 (14.8)	
Alcohol, n (%)				0.66
Never drunk	137 (50.4)	113 (82.5)	24 (17.5)	
Ever drunk	135 (49.6)	114 (84.4)	21 (15.6)	
Vegetable and fruit intake, n (%)				0.42
<5 servings per day	173 (63.6)	142 (82.1)	31 (17.9)	
≥5 servings per day	99 (36.4)	85 (85.9)	14 (14.1)	
Number of days for vegetable and fruit intake, n (%)				0.057
≤ 4 days	178 (65.4)	143 (80.3)	35 (19.7)	
> 4 days	94 (34.6)	84 (89.4)	10 (10.6)	
Dinner time, n (%)				0.050
Before 8pm	127 (46.7)	100 (78.7)	27 (21.3)	
After 8pm	145 (53.3)	127 (87.6)	18 (12.4)	
Physical activity (MET-mins per week): Median (IQR)	2074.5 (657-3988)	2697 (1188-4464)	396 (0-594)	**<0.001**
Physical activity (MET-mins per week): Median (IQR), n (%)				**<0.001**
<600	68 (25.0)	33 (48.5)	35 (51.5)	
≥600	204 (75.0)	194 (95.1)	10 (4.9)	
PHQ9 Score: Median (IQR)	7 (4-13)	7 (4-12)	12 (6-18)	**<0.001**
Depression, n (%)				**<0.001**
1-9(Minimal depression)	161 (59.2)	141 (87.6)	20 (12.4)	
10-14(Moderate depression)	57 (21.0)	51 (89.5)	6 (10.5)	
15-27(Severe depression)	54 (19.9)	35 (64.8)	19 (35.2)	
Sleep duration, n (%)				0.83
<5hours	5 (1.8)	4 (80.0)	1 (20.0)	
5-7hours	75 (27.6)	62 (82.7)	13 (17.3)	
>7hours	192 (70.6)	161 (83.9)	31 (16.1)	
Diabetes Mellitus, n (%)				**0.005**
No	222 (81.6)	192 (86.5)	30 (13.5)	
Yes	50 (18.4)	35 (70.0)	15 (30.0)	
Hypertension				0.14
No	177 (65.1)	152 (85.9)	25 (14.1)	
Yes	95 (34.9)	75 (78.9)	20 (21.1)	
Family history of Diabetes Mellitus, n (%)				0.57
No	159 (58.5)	131 (82.4)	28 (17.6)	
Yes	113 (41.5)	96 (85.0)	17 (15.0)	

(*continued on next page*)

Table 2 (*continued*)

Variable	Total N=272	Probable dementia		p-value
		Absent N=227	Present N=45	
Family history of Hypertension, n (%)				0.66
No	177 (65.1)	149 (84.2)	28 (15.8)	
Yes	95 (34.9)	78 (82.1)	17 (17.9)	
Family history of cardiovascular diseases, n (%)				0.40
No	261 (96.0)	219 (83.9)	42 (16.1)	
Yes	11 (4.0)	8 (72.7)	3 (27.3)	
Family history of Dementia, n (%)				0.43
No	218 (80.1)	180 (82.6)	38 (17.4)	
Yes	54 (19.9)	47 (87.0)	7 (13.0)	
Waist circumference(cm): Median (IQR)	85.5 (78-95)	86 (78-95)	85 (78-93)	0.76
Waist circumference(cm), n (%)				0.47
Normal	122 (44.9)	104 (85.2)	18 (14.8)	
High	150 (55.1)	123 (82.0)	27 (18.0)	
Waist to hip ratio: Median (IQR)	0.88 (0.83 - 0.93)	0.88 (0.83 - 0.93)	0.89 (0.83 -0.96)	0.31
Waist to hip ratio, n (%)				0.96
Normal	126 (46.3)	105 (83.3)	21 (16.7)	
High	146 (53.7)	122 (83.6)	24 (16.4)	
Systolic blood pressure (mmHg) : Median (IQR)	134 (121-151)	133 (121-151)	137 (124-153)	0.44
Systolic blood pressure (mmHg), n (%)				0.63
<140	154 (56.6)	130 (84.4)	24 (15.6)	
≥140	118 (43.4)	97 (82.2)	21 (17.8)	
Diastolic blood pressure (mmHg): Median (IQR)	82 (75.5-90)	82 (75-89)	84 (77-96)	0.39
Diastolic blood pressure (mmHg), n (%)				0.37
<90	202 (74.3)	171 (84.7)	31 (15.3)	
≥90	70 (25.7)	56 (80.0)	14 (20.0)	
Mid upper Arm circumference: Median (IQR)	28 (26-30)	29 (26-31)	26 (25-30)	**0.030**
Total cholesterol (mg/dL): Median (IQR)	158(136-184.9)	156(134-183)	172(140-199)	**0.019**
Total cholesterol (mg/dL), n (%)				0.16
<200	225 (82.7)	191 (84.9)	34 (15.1)	
≥200	47 (17.3)	36 (76.6)	11 (23.4)	
LDL-Cholesterol(mg/dL): Mean ± SD	98.88 ± 35.02	97.50 ± 34.99	105.85 ±34.67	0.14
LDL-Cholesterol(mg/dL), n (%)				0.51
<130	221 (81.3)	186 (84.2)	35 (15.8)	
≥130	51 (18.8)	41 (80.4)	10 (19.6)	
HDL-Cholesterol(mg/dL): Median (IQR)	38.55 (28.85-48.4)	38.6 (30.6-48.2)	35.2 (23-48.6)	0.46
HDL-Cholesterol(mg/dL), n (%)				0.59
Normal	88 (32.4)	75 (85.2)	13 (14.8)	
Abnormal (<40 for male, <50 for female)	184 (67.6)	152 (82.6)	32 (17.4)	
Dyslipidemia, n (%)				0.32
Absent	33 (12.1)	30 (90.9)	3 (9.1)	
Present	239 (87.9)	197 (82.4)	42 (17.6)	
Total cholesterol to HDL-cholesterol ratio: Median (IQR)	4.37(3.34-5.58)	4.30 (3.23-5.37)	4.56 (3.86-6.01)	0.058
Total cholesterol to HDL-cholesterol ratio, n (%)				0.099
<5	180(66.2)	155 (86.1)	25(13.9)	
≥5	92(33.8)	72(78.3)	20(21.7)	
Triglycerides (mg/dL): Median (IQR)	163.5 (119.5-215.5)	163(117-209)	191(138-222)	0.11
Triglycerides (mg/dL), n (%)				0.54
<150	120 (44.1)	102 (85.0)	18 (15.0)	
≥150	152 (55.9)	125 (82.2)	27 (17.8)	

also significantly linked to probable dementia ($p<0.001$). The median PHQ-9 score was higher among participants with probable dementia (12, IQR: 6–18) compared to those without (7, IQR: 4–12). Furthermore, probable dementia was most prevalent(35.2%) in participants with severe depression (PHQ-9 score: 15–27) compared to 10.5% and 12.4% prevalences observed in those with moderate (PHQ-9 score:10-14) and minimal depression(PHQ-9 score:1-9) ($p<0.001$).Diabetes mellitus was significantly associated with probable dementia ($p=0.005$), with 30.0% prevalence in individuals with diabetes compared to 13.5% prevalence in those without diabetes. Additionally, participants with probable dementia had significantly higher TC levels (median: 172 mg/dL, IQR: 140–199) compared to those without probable dementia (156 mg/dL, IQR: 134–183, $p=0.019$). Nutritional status, assessed using MUAC, also showed a significant association with probable dementia ($p=0.030$). Participants with probable dementia had a lower median MUAC of 26 cm (IQR: 25–30) compared to 29 cm (IQR: 26–31) among those without probable dementia.

3.3. Association of dyslipidemia and probable dementia

Our study findings (Table 3) indicate a significant and independent association between high TC/HDL-C ratio and probable dementia. A one-unit increase in the TC/HDL-C ratio was significantly associated with 13% higher odds of probable dementia (aOR: 1.13, 95% CI: 1.01–1.25, $p=0.027$). Age and physical activity were also observed to be significantly associated with higher odds of probable dementia. Each additional year of age was associated with 27% higher odds of probable dementia (aOR: 1.27, 95% CI: 1.16–1.39, $p<0.001$). Similarly, low physical activity (<600 MET-mins/week) was associated with 3.55-fold higher odds of probable dementia compared with higher physical activity (≥600 MET-mins/week) (aOR: 3.55, 95% CI: 1.04–12.08, $p=0.042$). Although Diabetes Mellitus, education level and depression showed significant associations with probable dementia in the bivariate analysis, these relationships were not maintained after adjusting for confounders (Table 3).

4. Discussion

According to our study, the prevalence of probable dementia in Rukiga district was 16.5%(95%CI: 12.8 - 21.5). This result is in line with the findings of studies conducted in a rural region of southwestern Uganda 20% [11]; Lira district northern Uganda, 23.0% (95% CI 19.2–27.3) [13], and St. Mary's Hospital Lacor in northern Uganda, 17.7 [41]%. Our findings are also in agreement from a Scoping Review of

Table 3
Association of dyslipidemia and probable Dementia.

Variable	Bivariate analysis		Multivariate analysis	
	cOR(95% CI)	P-value	aOR(95% CI)	P-value
Age(Years)	**1.28(1.20 - 1.37)**	**<0.001**	**1.27(1.16 -1.39)**	**<0.001**
Gender				
Male	1.00		1.00	
Female	1.71(0.85 - 3.43)	0.132	0.89(0.22 -3.68)	0.877
Education level				
No education	1.00		1.00	
Primary	**0.22(0.09 – 0.52)**	**0.001**	0.27(0.06 – 1.33)	0.109
Secondary/Tertiary	**0.19(0.04 -0.85)**	**0.030**	0.37(0.05 – 2.97)	0.347
Smoking				
Never smoked	1.00			
Ever smoked	0.85(0.37 -1.95)	0.703		
Alcohol				
Never drunk	1.00			
Ever drunk	0.87(0.46-1.65)	0.663		
Vegetable and fruit intake				
<5 servings per day	1.00			
≥5 servings per day	0.75(0.38-1.50)	0.421		
Number of days for vegetable and fruit intake				
≤ 4 days	1.00			
> 4 days	0.49(0.23 -1.03)	0.061		
Dinner time				
Before 8pm	1.00			
After 8pm	0.53(0.27 -1.01)	0.052		
Physical activity (MET-mins per week)				
≥600	1.00		1.00	
<600	**20.58(9.30 -45.51)**	**<0.001**	**3.55(1.04 – 12.08)**	**0.042**
Depression: PHQ9 Score				
1-9 (Minimal depression)	1.00		1.00	
10-14(Moderate depression)	0.83(0.32 -2.18)	0.705	0.49(0.10 -2.31)	0.365
15-27(Severe depression)	**3.83(1.85 -7.93)**	**<0.001**	1.75(0.47 -6.48)	0.401
Sleep duration				
<5hours	1.30(0.14 -12.01)	0.818		
5-7hours	1.09(0.53 -2.22)	0.814		
>7hours	1.00			
Diabetes Mellitus				
No	1.00		1.00	
Yes	**2.74(1.34 - 5.62)**	**0.006**	0.73(0.20 - 2.66)	0.635
Hypertension				
No	1.00		1.00	
Yes	1.62(0.85 -3.11)	0.145	0.44(0.13 -1.46)	0.179
Family history of Diabetes Mellitus				
No	1.00			
Yes	0.83(0.43 -1.60)	0.575		
Family history of Hypertension				
No	1.00			
Yes	1.16(0.60 -2.25)	0.661		
Family history of cardiovascular diseases				
No	1.00			
Yes	1.96(0.50 -7.67)	0.336		
Family history of Dementia				
No	1.00			
Yes	0.71(0.30 -1.68)	0.431		
Waist circumference(cm)				
Normal	1.00		1.00	
High	1.27(0.66 -2.43)	0.474	1.05(0.32 -3.40)	0.941
Waist to hip ratio				
Normal	1.00			
High	0.98(0.52 -1.87)	0.960		
Systolic blood pressure mmHg)				
<140	1.00			
≥140	1.17(0.62 -2.23)	0.627		
Diastolic blood pressure (mmHg)				
<90	1.00			
≥90	1.38(0.69 -2.78)	0.368		
Mid upper Arm circumference (cm)	0.94(0.87 -1.02)	0.121		
Total cholesterol (mg/dL)				
<200	1.00		1.00	
≥200	1.72(0.80 -3.70)	0.168	1.62(0.26 -9.98)	0.602
LDL-Cholesterol(mg/dL)				
<130	**1.00**		1.00	
≥130	1.30(0.59 -2.83)	0.514	0.94(0.16 -5.34)	0.942
HDL-Cholesterol(mg/dL)				
Normal	1.00		1.00	
Abnormal (<40 for male, <50 for female)	1.21(0.60 -2.45)	0.587	0.52(0.11 -2.47)	0.411
Dyslipidemia				
Absent	1.00		1.00	
Present	2.13(0.62 -7.31)	0.229	4.74(0.34 -66.26)	0.247
Total cholesterol to HDL-cholesterol ratio	1.04(0.98 -1.10)	0.219	**1.13(1.01 -1.25)**	**0.027**
Triglycerides (mg/dL)				
<150	1.00		1.00	
≥150	1.22(0.64-2.35)	0.543	0.58(0.17-1.94)	0.376

cOR:Crude odds ratios, aOR: adjusted odds ratios. All reported aORs, 95% confidence intervals, and p-values were estimated simultaneously from a single common final model

Population-Based Studies in East Africa which reported dementia prevalence to vary from 6–23% [42].However our finding is lower than the prevalence(46.2%) reported by study conducted at a faith-based geriatric center in Mukono [43]. The differences in the two prevalences may be attributed to the differences in the screening tools used for the classification of dementia status. Additionally, our study was a community-based study unlike the study in Mukono which was conducted at a geriatric center. Participants with probable dementia in our study were significantly older compared to those without dementia, a result that is consistent with findings from a cross-sectional community-based study in northern Uganda which found advanced age to be associated with probable or possible dementia [13]. Our study also found a significantly higher prevalence of probable dementia in participants with no formal education, lower physical activity levels, severe depression, and diabetes mellitus. These findings are in agreement with a Scoping Review of Population-Based Studies in East Africa which reports old age, lower education level, depression and physical inactivity

as risk factors for dementia and cognitive impairment [42] and a systematic review and meta-analysis which reported a high pooled prevalence of cognitive impairment of 43.99% among diabetic patients in Sub-Sharan Africa and a population-based cohort study in older adults which reported Diabetes as a significant risk factor for dementia [44]. A number of other studies have reported a significant association between diabetes mellitus and dementia [28,45,46] Additionally, participants with probable dementia had significantly higher total cholesterol levels and lower median MUAC compared to those without probable dementia. This is in agreement with previous studies that report hypercholesterolemia [2,15,16,23,28] and malnutrition [47–50] as risk factors for development of dementia and its severity.

Our study's prevalence was higher than estimates reported in several East Asian and Western populations, including 4.22% among Chinese adults aged ≥60 years in a nationwide DSM-IV–based survey [51], 6.5% among adults aged ≥65 years in England [52], and 8.8% among US adults aged ≥65 years in 2012 [53]; among US adults aged ≥72 years, probable dementia was 8.2% in 2021 [54]. Direct comparison should, however, be cautious because the present study used the CSID to identify probable dementia, whereas most comparator studies used clinical diagnostic criteria or validated cohort algorithms, and methodological heterogeneity is a recognized source of regional variation, particularly in East Asia [55]. The comparatively higher estimate in Rukiga may also reflect contextual differences in rural living, lower educational attainment, poor diet and low physical activity patterns, limited access to chronic disease care, and control of vascular-metabolic risks, including cholesterol, which are established contributors to dementia burden.

Our study found a significant association between TC/HDL-C ratio and probable dementia. TC/HDL-C ratio integrates both atherogenic and protective lipid fractions [56], offering a more comprehensive measure of lipid-related vascular risk. This ratio is reported as a better indicator than individual lipid parameters for Dyslipidemia and associated cardiovascular diseases [56–59] which have been evidently linked to risk of dementia [44,60,61]. However, this does not establish superiority of TC/HDL-C ratio over individual lipid parameter for identifying probable dementia. Therefore, the potential advantage of TC/HDL-C in relation to probable dementia remains hypothesis-generating and requires confirmation in longitudinal studies. The observed association in our study is consistent with findings from previous studies that reported elevated serum total cholesterol [2,15,16,23,28] and low levels of HDL-cholesterol [25,28,62–65] as risk markers of dementia and other neurocognitive disorders. The absence of significant associations between individual lipid fractions and probable dementia in the adjusted analyses may be partly attributable to the limited statistical power of our sample and residual confounding from biologically relevant factors, such as APOE genotype, statin use, and nutritional status, which were not assessed in this study. Furthermore, the cross-sectional design precluded the evaluation of longitudinal lipid trajectories and their temporal relationship with cognitive decline. Therefore, these findings should be interpreted cautiously and require confirmation in larger prospective studies incorporating repeated lipid measurements and assessment of additional biological determinants of dementia risk. Our multivariate analysis also identified significant associations of age and physical inactivity with higher odds of probable dementia, consistent with a study in northern Uganda [13] and a Scoping Review of Population-Based Studies in East Africa [42]. However, the association with physical activity should be interpreted cautiously because the cross-sectional design does not establish temporality. Reverse causation is plausible, whereby individuals with probable dementia may become less physically active because of cognitive or functional limitations. Therefore, our findings cannot establish whether low physical activity preceded probable dementia or occurred as a consequence of cognitive impairment. Longitudinal studies are needed to clarify the temporal direction of this association.

This study has several strengths. The community-based design facilitated the inclusion of older adults directly from their communities, providing valuable evidence from an understudied population in Southwestern Uganda. Probable dementia and physical activity were assessed using standardized screening instruments, while lipid parameters were measured from fasting blood samples using standardized laboratory procedures. The study also collected several relevant demographic, lifestyle, anthropometric, and clinical covariates, allowing assessment of potential confounding factors. These strengths enhance the characterization of the observed associations but do not establish diagnostic, predictive, temporal, or causal relationships.

This study also has some limitations that should be considered when interpreting the findings. First, the cross-sectional design provides only a snapshot of the prevalence of probable dementia and its association with serum lipoproteins, age, and physical activity levels, limiting the ability to establish causal relationships or determine the temporal sequence of these associations. The study design also precluded the assessment of longitudinal lipid trajectories and their relationship with cognitive decline, which may be more informative predictors of dementia risk than single lipid measurements. Second, the absence of significant associations for individual lipid fractions may have been influenced by limited statistical power and residual confounding from biologically relevant factors, such as APOE genotype, and nutritional status, which were not assessed in this study. Medication use with potential effects on serum lipid concentrations, particularly lipid-lowering therapy such as statins, was not systematically characterized. Therefore, residual confounding due to medication-related alterations in lipid concentrations cannot be excluded. Third, probable dementia was identified using the CSID, a validated screening tool widely used in low-resource settings, rather than a clinical diagnostic gold standard. Consequently, some degree of misclassification may have occurred, potentially inflating prevalence estimates and reducing the specificity of the observed associations.

Fourth, the multivariable analysis should also be interpreted cautiously because only 45 participants met the criterion for probable dementia. The final model contained 16 covariate parameters, corresponding to approximately three outcome events per parameter, which is below the conventional rule-of-thumb of 10 events per parameter. Consequently, model overfitting and instability of some adjusted estimates cannot be excluded, as reflected by the relatively wide confidence intervals for several covariates. Although no severe multicollinearity was detected and the Hosmer–Lemeshow test showed no evidence of lack of fit, these diagnostics do not eliminate the possibility of overfitting. Additionally, the regression analyses did not account for the clustered sampling structure at the village level. In addition, TC, HDL-C, LDL-C, dyslipidemia, and the derived TC/HDL-C ratio were included simultaneously in the exploratory multivariable model. Although VIF diagnostics did not indicate severe multicollinearity, the mathematical and biological interrelationships among these lipid measures should be considered when interpreting their adjusted estimates. The multivariable findings should therefore be regarded as exploratory and hypothesis-generating and require confirmation in larger studies with sufficient outcome events. Furthermore, the sample-size calculation used a simple prevalence-based formula and did not incorporate a design effect to account for the cluster sampling design. Consequently, if participants within sampled clusters were correlated, the effective sample size may have been smaller than assumed and the precision of the study estimates may have been overestimated. This should be considered when interpreting the findings, and future studies employing cluster sampling should account for the anticipated design effect in sample-size estimation. Finally, certain variables, including family history of dementia, diabetes mellitus, hypertension, and physical activity levels, were self-reported and may have been subject to inaccurate reporting.

Despite these limitations, this study provides important preliminary evidence on the relationship between serum lipoprotein ratios and probable dementia among older adults in Southwestern Uganda. Future prospective studies with repeated lipid assessments, evaluation of

relevant biological factors, and standardized clinical diagnostic approaches for dementia diagnosis, including comprehensive neurocognitive assessments and neuroimaging where feasible, are needed to validate these findings and clarify the role of lipoprotein markers in dementia risk prediction.

5. Conclusions

Probable dementia, as identified using the CSID, was relatively common among community-dwelling older adults in Southwestern Uganda. Higher TC/HDL-C ratio, advancing age, and low physical activity levels are potentially associated with probable dementia.

Ethics approval and consent to participate

This study was approved by the Faculty Research Committee (FRC) of Mbarara University of Science and Technology with approval number (MUST/MLS/030). Administrative clearance was also obtained from the Office of the District Health Officer, Rukiga District before conducting the study. Informed written consent was obtained from each of the study participants before their involvement in the study. This study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki (1964). Confidentiality of the study participants was observed by giving each participant a study code that was not traceable to them. Participants were also informed that their participation is free and voluntary and that they had a right to withdraw from the study at any time.

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Data availability

The datasets used in this study are available from the corresponding author upon reasonable request

CRediT authorship contribution statement

Dianah Ishimwe: Supervision, Methodology, Conceptualization. **Charles Nkubi Bagenda:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Ruth Tushemerirwe:** Supervision, Methodology, Conceptualization. **Jacinta Namugangu:** Supervision, Methodology, Conceptualization. **Rogers Mungufeni:** Supervision, Methodology, Conceptualization. **Patrick Unzima:** Supervision, Methodology, Conceptualization. **Elastus Ssemwanga:** Writing – review & editing, Writing – original draft, Visualization. **Carol Nantongo:** Writing – original draft, Visualization, Validation, Methodology. **Michael Junior Mugisa:** Writing – review & editing, Writing – original draft, Visualization. **Hope Mudondo:** Writing – review & editing, Writing – original draft, Visualization. **Lucas Ampaire:** Writing – review & editing, Visualization, Validation. **Enoch Muwanguzi:** Writing – review & editing, Visualization, Validation. **Catherine Abaasa:** Writing – review & editing, Visualization, Validation. **Samuel Ojuko:** Writing – review & editing, Visualization, Validation. **Fred Sempijja:** Writing – review & editing, Visualization, Validation. **Amos Oyuru:** Writing – review & editing, Writing – original draft, Visualization. **Benson Musinguzi:** Writing – review & editing, Writing – original draft, Visualization, Validation. **Winnie Akiteng:** Writing – review & editing, Writing – original draft, Visualization. **Lawrence Obado Osuwat:** Writing – review & editing, Writing – original draft, Visualization. **Simon Peter Rugera:** Writing – review & editing, Writing – original draft, Visualization, Validation. **Deusdedit Tusubira:** Writing – review & editing, Writing – original draft, Visualization, Validation.

Declaration of competing interest

The authors declare that they have no competing interests.

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