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Reference intervals for serum creatinine for healthy adults in central Africa: a *post-hoc* analysis

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Abstract

Background Despite current interest in creatinine-based equations for estimating glomerular filtration rate, the evaluation of creatinine reference intervals remains relevant. The present study aimed to establish such reference intervals from a healthy Congolese adult population and to investigate the determinants of serum creatinine.

Methods This study was based on *post-hoc* data of previous epidemiology studies conducted in the general population of Kinshasa. Serum Creatinine measurement was performed with the Roche Cobas (Roche Diagnostics, Mannheim, Germany) enzymatic method calibrated to Isotope Dilution Mass Spectrometry (IDMS) traceable. The creatinine values being not normally distributed, the median values and interquartile range and the 2.5th and 97.5th percentiles were considered. Serum creatinine determinants were investigated by a generalized linear model (GLM). A value of $p < 0.05$ was the threshold of statistical significance.

Results Of 2,504 Congolese adults screened, 506 (males, 67.7%) were healthy and were involved in this study. Their mean body surface area (BSA) was 1.64 ± 0.15 m^2. In males, the median of creatinine was 0.96 [0.87; 1.05] mg/dl and percentiles 2.5th and 97.5th were 0.65 and 1.22 mg/dL, respectively. The reference intervals were between 0.65 (90% confidence interval (CI): 0.63 to 0.67) and 1.22 (90% CI: 1.20 to 1.24) mg/dL for the lower limits (LL) and the upper limits (UL), respectively. In females, the median of creatinine was 0.72 [0.66; 0.80] mg/dl and percentiles 2.5th and 97.5th were 0.50 and 0.95 mg/dL, respectively. The reference intervals were between 0.50 (90%CI: 0.47 to 0.52) and 0.95 (90% CI: 0.93 to 0.98) mg/dL for the lower and the upper limits respectively. The factors independently associated with serum creatinine were age, female gender, the interaction between age and gender, weight, arm circumference, education level, and weekly walking frequency.

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Conclusion The reference intervals for serum creatinine for Congolese adults seem close to those of White Europeans, with slightly higher values in Congolese compared to Caucasians, but lower than those of the African-Americans. Constitutional factors and lifestyle impact serum creatinine levels.

Keywords Serum creatinine, Reference intervals, Determinants, Adults, Central Africa

Background

The burden of chronic kidney disease (CKD) is shared by all regions of the world but particularly affects sub-Saharan African countries (SSA) [1–7]. Indeed, CKD is highly prevalent among 8–17% of the population [8–12]. In Democratic Republic of the Congo (DRC), the prevalence of CKD has been estimated at 12% [12]. In clinical practice, renal function is quantified using glomerular filtration rate (GFR) and GFR is mostly estimated by creatinine-based equations. Serum creatinine is thus widely used in patients who have blood tests measured routinely [13–15]. However, interpretation of serum creatinine results is not always easy. The serum creatinine concentration depends mainly on GFR but also on muscular mass. This includes gender, weight, ethnicity, physical activity and age [13]. Inter-individual differences in serum creatinine levels, male-female, young-old, are essentially explained by differences in muscle mass [13]. Therefore, for the same level of GFR, serum creatinine could be different according to age and sex. Also, serum creatinine has been shown to have different normal reference values, for example, between White and Black Americans, even if the mechanism explaining such a difference is not perfectly known [16]. Despite current interest in creatinine-based equations for estimating glomerular filtration rate (eGFR), the evaluation of creatinine reference intervals remains relevant. However, in the African population, those values are poorly documented. Most previous data have considered serum creatinine measured by the Jaffe method and most were not traceable to Isotope Dilution Mass Spectrometry (IDMS) [17–19]. The present study aimed to determine the reference intervals of serum creatinine in a well-phenotyped population of healthy Congolese adults using an enzymatic IDMS traceable assay and to investigate the determinants of serum creatinine.

Methods

Study design, setting, and population

This *post-hoc* analysis study is based on a larger epidemiological survey on CKD and associated risk factors, carried out between June 2015 and April 2016, in the general population of Kinshasa, capital of the DRC [20]. Sampling of the study of population has been described in detail elsewhere [20].

Data collection

All participants were visited twice at home by trained research personnel, who recorded information on demographics, diet, smoking, alcohol consumption, and use of indigenous herbal remedies. Familial medical history for kidney disease, hypertension, diabetes and current treatment were also recorded.

Blood pressure (BP) was measured three times in a sitting position, in the left or right arm, at the heart level, using an OMRON M3 IntelliSense electronic monitor (model HEM-7051-E (V)). All participants could relax for five minutes before determination of BP, and an average of three BP measurements was considered. Pulse rate (beats per minute) was recorded at the wrist. Height(in meters) and weight(per Kilogram) were measured in standing position, without shoes, and wearing light clothing, using a wall-mounted stadiometer and a SECA weighing scale, respectively. Waist, hip, and arm circumferences were measured in centimeters with a measuring tape.

Participants were questioned about their educational attainment, which was categorized as: no formal education, primary, secondary, technical/professional, or university. Fruit intake frequency was recorded as once, twice, three times, or more than three times per week. For medicinal plant use, participants were classified as non-users or users. Details of plant (type, duration of use, regular intake or stop using completely for more than 6 months) were also recorded. Available lifestyle included also self- physical activity classified as active or not. For those who were active, the type of activity (mainly walking), frequency (times per week), and duration were precised."

The participants were screened for the absence of acute and chronic pathologies including hypertension, diabetes mellitus, obesity, cardiovascular diseases, known chronic kidney disease, and urinary abnormalities (proteinuria, hematuria or leucocyturia) by urine dipstick ("Combur10 Test", Roche Diagnostics, Mannheim, Germany) on the morning urine. Capillary glycemia was measured for all participants, using a One-Touch Ultra brand glucometer. Medication was not allowed except for contraceptives in the female. Participants were required to refrain from taking drugs may interfere with serum creatinine such as Co-trimoxazole or Cimetidine for at least one week before joining the study. Healthy participants did not have hypertension, diabetes mellitus, obesity, urinary abnormalities and known CKD.

Biochemical assays

Five milliliters of venous blood were collected by venipuncture in 1 dry tube of 5 ml. Serum was separated by centrifugation at 3000 rpm within 10 min, samples were stored at -80 °C and then were shipped to the clinical chemistry laboratory of the University of Liège, "Centre Hospitalier Universitaire de Liège" (CHU de Liège) in Belgium which is International Organization for Standardization (ISO) 15,189 compliant. Creatinine measures were performed with the Roche Cobas (Roche Diagnostics, Mannheim, Germany) enzymatic method calibrated against the National Institute of Standards and Technology Standard Reference Materials (NIST SRM) 967 whose concentration has been measured using the National Institute of Standards and Technology Liquid Chromatography/ Isotope Dilution Mass Spectrometry (NIST LC/IDMS) measurement procedurea. The coefficient of variation of the assay is < 2%.

Statistical analysis

A minimum of 120 participants was required for each sex group, in line with the International Federation of Clinical Chemistry's (IFCC) recommendations [21]. Data are expressed as mean ± standard deviation (SD) when distribution was normal and as median with interquartile range [quartile1; quartile 3] when not. Creatinine results were not normally distributed according to the Kolmogorov-Smirnov test, and therefore the median values, interquartile range and the 2.5th and 97.5th percentiles were considered. To better assess the assumption of non-normality, sex-specific histograms were used to visual inspect the distribution of creatinine levels (supplementary S1 and S2). Continuous variables were compared between age / sex groups, using the Student t test, or Mann-Whitney U test as appropriate. Reference intervals were determined both in males and females using the Clinical and Laboratory Standards Institute (CLSI) guidelines for percentiles. Outliners were detected according to the Tukey test. We tested if reference interval were age-related by Altman & Chitty, and Wright & Royston [21–25]. We also determined the 90% confidence intervals of upper and lower reference limits by gender according to IFCC recommendations [21]. We used a generalized linear model (GLM) with serum creatinine (SCr) as the dependent variable to identify factors associated with SCr levels. The model assumed a Gaussian distribution with an identity link function. Variable selection was performed using backward elimination, starting with all available covariates. At each step, the variable with the highest p-value was removed, and the model was refitted, continuing until only variables with $p < 0.05$ remained.

To assess the robustness of the model, we conducted a sensitivity analysis by excluding potentially influential observations. Specifically, participants with Cook's distance ≥ 0.008 (i.e., 4/506) were removed, resulting in a reduced sample of 476 participants. Model results for both the full sample ($n = 506$) and the reduced sample ($n = 476$) are presented (Supplementary fig. S3a and fig. S3b). All analyses and calculations were performed using Statistical Analysis System (SAS) 9.4 (SAS Institute Inc., Cary, NC, USA) and Medcalc (Mariakerke, Belgium).

Results

Population

Two thousand five hundred and four Congolese adults were screened. Among them, 1,998 were excluded from the study because they had hypertension, diabetes mellitus, obesity, chronic kidney disease or urinary dipstick abnormalities, leaving 506 subjects considered as healthy for the analysis (Fig. 1). There were 343 men (68%) and 163 women (32%), aged between 19 and 80 years old with a mean age of 34.3 ± 12.8 years. Characteristics of the subjects are described in Table 1. The mean height, weight, body surface area (BSA) and body mass index (BMI) were 166.8 ± 9.0 cm, 57.7 ± 8.3 kg, 1.64 ± 0.15 m^2 and 20.7 ± 2.1 kg/m^2, respectively. Differences between men and women are also described in Table 1.

Reference intervals

Results are summarized in Table 2. As expected, the median concentration of creatinine was higher in males 0.96 [0.86; 1.05] mg/dL than in females 0.72 [0.66; 0.80] mg/dL ($p < 0.0001$). In males, six creatinine values were excluded after applying the Tukey test. The median concentration was 0.96 [0.86;1.05] mg/dl and percentiles 2.5th and 97.5th were 0.65 and 1.22 mg/dL, respectively. The reference intervals were between 0.65 (90% Confidence interval (CI): 0.63 to 0.67) mg/d for the lower limit (LL) and 1.22 (90% CI: 1.20 to 1.24) mg/dL for the upper limit (UL). Reference intervals were not influenced by age (Fig. 2) for the men. In females, two creatinine values were excluded after applying the Tukey test. The median concentration was 0.72 [0.66; 0.80] mg/dl and percentiles 2.5th and 97.5th were 0.50 and 0.95 mg/dL, respectively. The reference intervals were between 0.50 (90%CI: 0.47 to 0.52) mg/dL for the lower limit and 0.95 (90%CI: 0.93 to 0.98) mg/dL for the upper limit. Median and mean were very close, and also the 2.5th and 97.5th percentiles were close to the LL and UL respectively (supplementary Table S1).

Determinants of creatinine in generalized linear model

Variables associated with serum creatinine values are presented in Table 3a, and model fit diagnostics are shown in Supplementary Fig. S3a. Using the GLM on all 506 participants, only gender and the interaction of age and gender were independently associated with serum

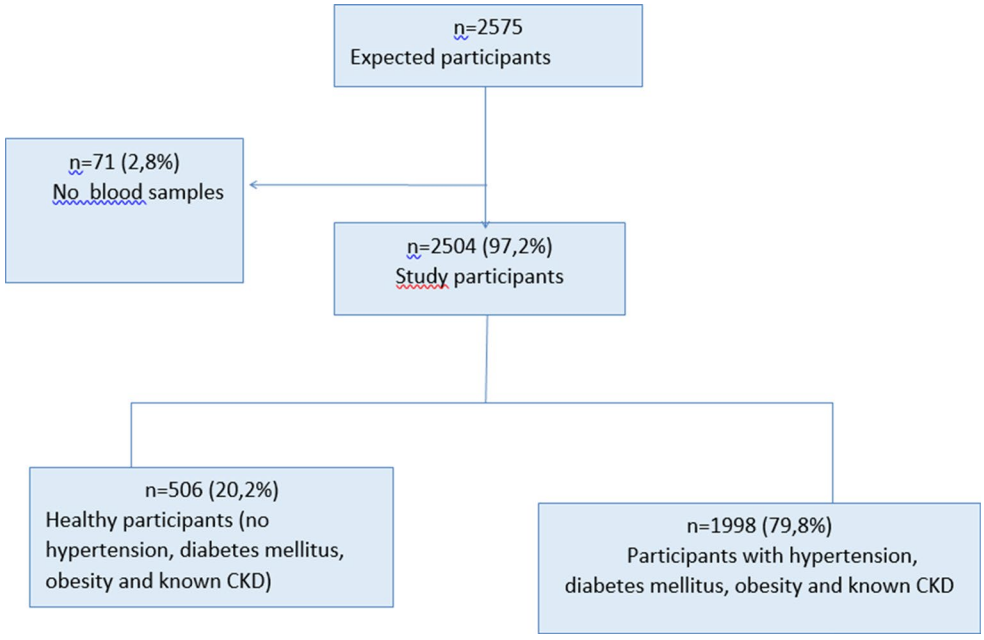

Fig. 1 Flow diagram of the study population

Table 1 General characteristics of study population

Variables	All $n=506$	Males $n=343$	Females $n=163$	*P* value
Age (years)	34.3 ± 12.8	35.5 ± 13.0	31.8 ± 11.9	0.003
Weight (kg)	57.7 ± 8.3	60.2 ± 7.9	52.3 ± 6.4	< 0.001
Height (cm)	166.8 ± 9.0	170.3 ± 7.7	159.4 ± 6.7	< 0.001
BSA (m^2)	1.60 ± 0.14	1.64 ± 0.13	1.51 ± 0.11	< 0.001
BMI (Kg/m^2)	20.7 ± 2.1	20.8 ± 2.2	20.6 ± 2.1	0.207
Waist (cm)	74.7 ± 6.0	75.8 ± 6.2	72.5 ± 4.8	< 0.001
Hip circumference (cm)	89.7 ± 5.6	89.6 ± 5.6	89.8 ± 5.7	0.314
SBP (mmHg)	119.7 ± 10.2	121.6 ± 9.5	115.7 ± 10.5	< 0.001
DBP (mmHg)	72.1 ± 7.9	73.3 ± 8.0	72.9 ± 7.7	0.298
MAP (mmHg)	88.7 ± 7.8	89.4 ± 7.7	87.1 ± 7.8	0.001
PP (mmHg)	46.5 ± 8.6	48.3 ± 8.1	42.8 ± 8.5	< 0.001
Creatinine (mg/dL)	0.88 ± 0.12	0.95 ± 0.14	0.73 ± 0.11	< 0.001
Fasting glycemia (mg/dL)	84.9 ± 12.6	84.5 ± 12.8	86.2 ± 11.7	0.265

Mean with SD, $p < 0.05$, abbreviations: BMI (Kg/m2): body mass index, BSA: Body surface area, DBP (mmHg): Diastolic blood pressure, MAP (mmHg): Mean blood pressure, PP (mmHg): pulse pressure, SBP (mmHg): Systolic blood pressure

Table 2 Reference intervals for serum creatinine by gender

Variables	Creatinine (mg/dl)			*P*
	Median	2.5th percentile (90% CI)	97.5th percentile (90% CI)	
Males : 343	0.96 (0.86–1.05)	0.65 (0.63–0.67)	1.22 (1.20–1.24)	< 0.001
Females : 163	0.72 (0.66–0.80)	0.50 (0.47–0.52)	0.95 (0.93–0.98)	

Median, $p < 0.05$, abbreviations: RI: Reference Interval; 90% CI, CI: confidence interval

creatinine values. After deleting all observations with Cook's distance ≥ 0.008 (4/506) and rerunning the GLM with 476 participants, variables associated with higher serum creatinine were: age, the interaction of age with female gender, weight, and arm circumference. Variables associated with lower serum creatinine were: female gender, study level 'No level' (compared to University), and walking once a week (compared to four times a week) (Table 3b). Model fit diagnostics indicate an adequate model fit (Supplementary Fig. S3b).

Discussion

To our knowledge, this is the first study establishing the reference intervals for serum creatinine in Congolese adults. In line with the IFCC recommendations [21], serum creatinine was measured by an enzymatic method calibrated at IDMS. The reference intervals were 0.65, 1.22 mg/dL, 0.50, and 0.95 mg/dL in males and females, respectively with median values of 0.96 mg/dL for males and 0.72 mg/dL for females. Reference intervals were slightly influenced by age in females (Fig. 2), but not in males. Age, female gender, the interaction of age with gender, weight, arm circumference, study level (no level) and weekly walk 1 were independently associated with serum creatinine value.

As expected, serum creatinine in men was higher than women in all age groups. These gender-related variations in serum creatinine were reported by several African and non-African studies. In 2012, a study in Kinshasa school setting, among adolescents aged 16 to 24, reported the percentiles 2.5th and 97.5th for serum creatinine of 0.66

Fig. 2 Age related reference intervals of creatinine by gender. (**a**) Age related reference intervals of creatinine for Males. (**b**) Age related reference intervals of creatinine of Females. Figure **a** shows that serum creatinine does not increase with age in men. In contrast, Figure **b** shows a slight increase in serum creatinine with age in women. However, as there are fewer women aged 50 and over, this result must be interpreted with caution

and 1.26 mg/dL, respectively in males and 0.62 mg /dL and 1.43 mg /dL, respectively in females [26].

In this previous Congolese study, serum creatinine was measured by Jaffe method not calibrated at IDMS. The discrepancy with the current results is probably analytical.

It is well known that enzymatic creatinine is lower than results obtained with Jaffe method. However, the results change from one analyzer to another even if the same method is used [13]. This makes sense of standardizing creatinine results for all methods. Standardization of creatinine results improves the assessment of kidney function [27]. However, the influence of age on serum

Table 3a Determinants of serum creatinine in generalized linear model with all participants

Parameter	Coefficient	Standard Error	t Value	Pr > |t|
Intercept	0.4272088011	0.22740493	1.88	0.0609
Age	0.0004504261	0.00066186	0.68	0.4965
Gender F	−0.2416402507	0.04193541	-5.76	< 0.0001
Gender M	Ref	.	.	.
Age*Gender F	0.0021414695	0.00108691	1.97	0.0494
Age*Gender M	Ref	.	.	.
Weight (Kg)	0.0011491098	0.00158129	0.73	0.4678
Height(m)	0.0014289834	0.00107658	1.33	0.1850
Waist circumference(cm)	0.0009474936	0.00155629	0.61	0.5429
Hip circumference(cm)	0.0008123704	0.00157372	0.52	0.6059
Arm circumference (cm)	0.0048023878	0.00334210	1.44	0.1514
SBP(mmHg)	−0.0006974851	0.00076987	-0.91	0.3654
DBP(mmHg)	0.0007174719	0.00093386	0.77	0.4427
Pulse (minute)	−0.0002918437	0.00049970	-0.58	0.5595
Study Level 0 No LEVEL	−0.0636073064	0.04761916	-1.34	0.1823
Study Level PRIMARY (1–6)	−0.0243399355	0.02605134	-0.93	0.3506
Study Level SECONDARY (7–12)	−0.0144689281	0.01386194	-1.04	0.2971
Study Level TECHNICAL/PROFESSIONNAL	0.0078472306	0.02861522	0.27	0.7840
Study Level UNIVERSITY	Ref	.	.	.
Fruit Intake No	−0.0237407235	0.01807244	-1.31	0.1896
Fruit Intake YES	Ref	.	.	.
Sport No	0.0095028528	0.01444699	0.66	0.5110
Sport YES	Ref	.	.	.
Weekly Walk 0	−0.0348125699	0.01824921	-1.91	0.0570
Weekly Walk 1	−0.0100660169	0.01681319	-0.60	0.5497
Weekly Walk 2	0.0188034939	0.01726567	1.09	0.2767
Weekly Walk 3	−0.0157148305	0.02114260	-0.74	0.4577
Weekly Walk 4	Ref	.	.	.
Natural Plant Intake No	−0.0230580244	0.03493045	-0.66	0.5095
Natural Plant Intake YES	0.0080315420	0.03604443	0.22	0.8238
Natural Plant Intake cessation over 6 months	Ref	.	.	.

DBP = diastolic blood pressure, SBP = systolic blood pressure, M = male, F = female, Ref = Reference, Weekly Walk 0: no physical activity, Weekly Walk 1: once weekly, Weekly Walk 2: twice weekly, Weekly Walk 3: three times weekly, Weekly Walk 4: four times weekly. Study Level 0: no study or without level

creatinine levels cannot be completely discounted, particularly since several factors, such as age and gender, can affect these levels in healthy subjects. The 2012 study involved adolescents and young adults in a school setting, whereas the present study concerned the general adult population.

In Côte d'Ivoire (West Africa), a study was conducted by Yao et al. in healthy subjects who donated blood, with serum creatinine assayed by a calibrated enzymatic method [18]. They reported serum creatinine values similar to the current study. The reference intervals for Congolese males and females seem close to the reference intervals of White Europeans males and females: [0.65–1.23 mg/dL] for males and [0.50–0.95 mg/dL] for females with median values of 0.96 mg/dL and 0.72 mg/dL respectively [27]. There is a slight difference in median values between Belgian and Congolese subjects: for males 0.96 mg/dL vs. 0.90 mg/dL; for females 0.72 mg/dL versus 0.70 mg/l [28].

In contrast, Congolese creatinine reference intervals were lower than those reported in Cameroon by Edinga-Melenge et al.., these authors found a reference intervals serum creatinine of 0.74–1.36 mg / dL (P2.5-97.5th) for males and 0.58–1.08 mg / dL (P2.5-97.5th) for females [17]. American studies have described higher serum creatinine reference ranges in the African American population compared to the white population [29].

The data from this study corroborate those from these different studies showing higher reference intervals for males than females in all age groups [17].

This variation would probably be linked to the difference in muscle mass between these different populations. Indeed, serum creatinine is the catabolite of muscle creatine which is synthesized mainly at the hepatic level. Daily, 1% to 2% of muscle creatine is converted into

Table 3b Determinants of serum creatinine in generalized linear model with 476 participants

	Estimate		Standard Error	t Value	*P*
Intercept	0.6192380658	B	0.06313239	9.81	< 0.001
Age	0.0010082916	B	0.00050168	2.01	0.045
Gender F	−0.2542787759	B	0.03208161	-7.93	< 0.001
Gender M	Ref	B	.	.	.
Age*Gender F	0.0025337475	B	0.00091577	2.77	0.006
Age*Gender M	Ref	B	.	.	.
Weight (Kg)	0.0026033998		0.00088817	2.93	0.004
Arm Circumference (cm)	0.0056216949		0.00263541	2.13	0.033
Study Level 0 No LEVEL	−0.0916474331	B	0.04415917	-2.08	0.039
Study Level PRIMARY (1–6)	−0.0204378133	B	0.02208272	-0.93	0.355
Study Level SECONDARY (7–12)	−0.0073028800	B	0.01147195	-0.64	0.525
Study Level TECHNICAL/ PROFESSIONNAL	0.0176390477	B	0.02497543	0.71	0.480
Study Level UNIVERSITY	Ref	B	.	.	.
Weekly Walk 0	−0.0180200640	B	0.01538436	-1.17	0.242
Weekly Walk 1	−0.0331175586	B	0.01431509	-2.31	0.021
Weekly Walk 2	0.0270273132	B	0.01460480	1.85	0.065
Weekly Walk 3	−0.0066710238	B	0.01768883	-0.38	0.706
Weekly Walk 4	Ref	B	.	.	.

DBP = diastolic blood pressure, SBP = systolic blood pressure, M = male, F = female, Ref = Reference, Weekly Walk 0: no physical activity, Weekly Walk 1: once weekly, Weekly Walk 2: twice weekly, Weekly Walk 3: three times weekly, Weekly Walk 4: four times weekly. Study Level 0: no study or without level

creatinine. It is obvious that the serum creatinine concentrations are above all dependent on muscle mass. Thus, in the absence of any kidney disease, the differences in serum creatinine concentrations that can be observed between men and women, between old and young people, between different ethnic groups can be explained by differences in muscle mass [30, 31]. However, this explanation remains hypothetical. The role of diet, notably the amount of meat, could also be important to explain such differences between populations. Further studies are still required.

Comparing creatinine reference intervals across age groups, no influence of age was noted in males but a small influence of age was observed for females. These results must however be interpreted with caution as the number of subjects older than 50 years old in our study is limited.

In the presented study, serum creatinine (SCr) levels were associated with gender, an interaction between age and gender, weight, arm circumference, educational level, and weekly walking frequency. Gender emerged as the strongest predictor, with lower SCr levels observed in females compared to males, consistent with known physiological differences in muscle mass and creatinine metabolism [13]. The interaction between age and gender suggests that the relationship between age and SCr differs by sex, with a slightly steeper increase in SCr with age among women. However, this interaction should be interpreted with caution because the number of older participants in the sample was relatively small. Weight and arm circumference were also positively associated with SCr, likely reflecting their role as proxies for muscle mass [32–35]. Educational level showed a negative association with SCr for individuals with no formal education compared to those with university-level education. Although education itself is unlikely to directly influence creatinine levels, it may act as a proxy for socioeconomic status, which can affect diet quality, including intake of creatine-rich foods such as meat [13]. Higher education levels are also often associated with better access to healthcare and healthier lifestyles, which may indirectly influence kidney function [34, 36, 37]. However, the observed association in our sample may also reflect differences in body composition or other unmeasured factors, and should therefore be interpreted with caution.

The association between weekly walking frequency and SCr was inconsistent. While moderate physical activity such as walking is generally considered beneficial for kidney health [38–40]. The observed pattern, where some walking categories had negative and others positive associations relative to the reference, lacks a clear biological explanation and may reflect residual confounding or measurement error. Finally, any association was observed between reported use of medicinal plants and SCr levels. However, the heterogeneity in the types, timing, and dosages of these products limits the interpretability of this finding.

Strengths

This study will help to fill a gap that is the scarcity of data on serum creatinine reference intervals in sub-Saharan Africa. This study was carried out in the general population and established for the first time reference intervals for serum creatinine in the adult population of the Democratic Republic of Congo (DRC). Serum creatinine was analyzed using an IDMS-calibrated enzymatic method that is therefore traceable. This study made it possible to determine the median creatinine specific to the African adult population, an important value for estimating glomerular filtration rate using the European Kidney Function (EKFC) equation [41].

Limitations

This study established reference ranges only for adults in the DRC, not for children. In addition, it did not include a large number of women over 50 years of age to better analyze the possible influence of age on serum creatinine.

Data on medicinal plant intake was qualitative, not quantitative. Constituents were not quantified. Those are participants' declarations, not verifiable information. The study was conducted in urban rather than rural areas.

Conclusion

For the first time, we established the reference intervals for serum creatinine for Congolese males and females seem close to the reference intervals for serum creatinine of White Europeans males and females, with slightly higher values. As expected, men have higher reference values than women. Constitutional and lifestyle factors were associated with serum creatinine levels.

Abbreviations

BMI	Body mass index
BSA	Body surface area
CKD	Chronic kidney disease
CKD-EPI	Chronic Kidney Disease Epidemiology
CI	Confidence interval
CLSI	Clinical & Laboratory Standards Institute
DBP	Diastolic blood pressure
DRC	Democratic Republic of the Congo
FAS	Full Age Spectrum
GFR	Glomerular filtration rate
IDMS	Isotope dilution mass spectrophotometry
IFCC	Federation of Clinical Chemistry's
IQR	Interquartile range
ISO	International Organization for Standardization
MAP	Mean blood pressure
NIST/ SRM	National Institute of Standards and Technology/Standard Reference Material
pp	Pulse pressure
Ref	Reference
RI	Reference interval
SBP	Systolic blood pressure
SCr	Serum creatinine
SD	Standard deviation
SSA	Sub-saharian Africa

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12882-025-04538-w.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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Author contributions

Justine Bukabau, Ernest Sumaili and Pierre Delanaye conceived and designed the study. Justine Bukabau, Aliochia Nkodila, Pierre Delanaye, Hans Pottel, Ernest Sumaili, Etienne Cavalier and Jean-Robert Makulo analysed data, performed the statistical analysis and interpreted data. Justine Bukabau drafted the manuscript. Justine Bukabau, Ernest Sumaili, Pierre Delanaye, Etienne Cavalier, Hans Pottel, Jean-Robert Makulo, Vieux Mokoli, Aliochia Nkodila, François-Patanleon Kajingulu, Chantal Zinga, Augustin Longo, Yannick Engole, Yannick Nlandu, Marie-France Mboliasa and Nazaire Nseka revised the manuscript. All authors approved the final submitted version for publication and have agreed to be accountable for all aspects of the work.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study was conducted with strict respect for human dignity. Data were collected on individual forms, anonymously and confidentially, in strict compliance with the Declaration of Helsinki. All aspects and procedures related to the study were explained to each potential participant. The study protocol was approved by the Ethics Committee of the School of Public Health, University of Kinshasa (N°ESP/CE/029/2015) and by the institutional evaluation committees of each site. Written informed consent was obtained in advance from all participants. Those with abnormal results received counseling and educational leaflets, and were managed at the nephrology unit of Kinshasa University Hospital.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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