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Accuracy of the novel Peguero Lo-Presti criterion for electrocardiographic detection of left ventricular hypertrophy in a black African population

Ulrich Flore Nyaga MD[1] 🟢 | Jerôme Boombhi MD[1,2] | Alain Menanga MD[1,2] | Morike Mokube MD[1] | Carine Sandrine Ndomo Mevoula MD[1] | Samuel Kingue MD[1,2] | Jean Jacques Noubiap MD, MMed[3] 🟢

[1]Department of Internal Medicine and Specialties, Faculty of Medicine and Biomedical Sciences, Yaoundé, Cameroon

[2]Division of Cardiology, Department of Medicine, Yaoundé General Hospital, Yaoundé, Cameroon

[3]Centre for Heart Rhythm Disorders, University of Adelaide and Royal Adelaide Hospital, Adelaide, Australia

Correspondence
Ulrich F. Nyaga, Department of Internal Medicine and Specialties, Faculty of Medicine and Biomedical Sciences, Yaoundé, Cameroon.
Email: nyagaflore@gmail.com

Abstract

The diagnostic accuracy of the electrocardiogram for left ventricular hypertrophy (LVH) is limited. Recently, Peguero and collaborators proposed a novel voltage criterion for its detection with reportedly higher accuracy than the commonly used Cornell and Sokolow-Lyon criteria. While studies done in various populations have confirmed it, there are no available data from black African populations. We conducted a cross-sectional study in a population from Cameroon to compare the Peguero-Lo Presti criterion to the older Cornell, Sokolow-Lyon, and Cornell product criteria, pertaining to their sensitivity, specificity, and area under the receiver operating characteristic curve (AUC), with echocardiography as the reference standard. The study population consisted of 238 participants (54.2% female) with a mean age of 58 (SD 13) years. On echocardiography, the prevalence of LVH was 45.3% (n = 108). The sensitivity was 48.14%, 63.89%, 63.89%, and 67.29% for the Sokolow-Lyon, Peguero-Lo Presti, Cornell, and Cornell product criteria, respectively. The specificity was 73.84%, 75.97%, 79.23%, and 82.31% for the Peguero-Lo Presti, Cornell product, Cornell, and Sokolow-Lyon criteria, respectively. The overall accuracy of the Peguero-Lo Presti (AUC = 0.689) was not significantly different from that of the Cornell (AUC = 0.714), the Cornell product (AUC = 0.717), and the Sokolow-Lyon (AUC = 0.652) (all p > .05). Hypertension and gender influenced the agreement between ECG criteria and echocardiography in the detection of LVH. In conclusion, in this black African population, Peguero-Lo Presti was not significantly more or less accurate than Cornell or Sokolow-Lyon.

1 | INTRODUCTION

Left ventricular hypertrophy (LVH), a maladaptive response to chronic pressure overload, is a marker of subclinical cardiac disease and a predictor of arrhythmias, heart failure, and death.[1,2] Because LVH is potentially reversible, its early detection and appropriate management of its underlying cause can prevent related adverse cardiovascular outcomes.[3] In routine clinical practice, LVH is usually

screened for using electrocardiography and further confirmed by echocardiography or cardiac magnetic resonance imaging.[4] Although electrocardiography is a cost-effective tool for the screening of LVH, electrocardiographic criteria such as the commonly used Sokolow-Lyon and Cornell have limited accuracy, especially a low sensitivity.[4]

In 2017, Peguero, Lo Presti and colleagues proposed a novel and simple criterion (Peguero-Lo Presti) for the electrocardiographic screening of LVH that performed better than Sokolow-Lyon and Cornell in their validation cohort.[5] A recent systematic review and meta-analysis showed that Peguero-Lo Presti had a higher accuracy than Cornell and Sokolow-Lyon criteria, propounding that it might be more appropriate for routine screening of LVH.[6] However, a large study from China that was not included in this meta-analysis suggested that with improved cutoff values, Cornell could be better than Peguero-Lo Presti.[7]

The accuracy of LVH electrocardiographic criteria varies according to ethnicity or race.[4,8] No previous study has assessed the diagnostic performance of the Peguero-Lo Presti criterion in a black African population. Hence, this study was conducted to compare the Peguero-Lo Presti to the popular Sokolow-Lyon and Cornell, and to the less commonly used Cornell Product in a population from Cameroon.

2 | METHODS

2.1 | Study design, setting, and population

This study was conducted between December 2019 and September 2020 at the Yaoundé General Hospital, an academic and tertiary hospital in the capital city of Cameroon. Cameroon has approximately 250 ethnic groups,[9] with a population estimated at about 25.9 million inhabitants in 2019 (World Bank data). We considered as eligible all participants who were aged 18 years or more, who underwent echocardiography and electrocardiography on the same day during the study period. We excluded patients with (i) pregnancy; (ii) chest deformity (scoliosis, kyphosis, pectus excavatum, and pectus carinatum); (iii) chronic obstructive pulmonary disease; (iv) bedridden condition; (v) right or left bundle branch block; (vi) ventricular rhythm; and (vii) technically difficult echocardiography. All eligible patients who presented during the study period were approached for participation to the study, and those who consented were included.

2.2 | Procedure

All participants had a 12-lead electrocardiogram performed at rest in the supine position by a trained technician using a commercially available device (Cardiofax S, Nihon Kohden) and according to standard procedures (speed and voltage regulation of 25 mm/s and 1 mV/10 mm, respectively). They also underwent a transthoracic echocardiography in the left lateral decubitus position, done by an experienced cardiologist blinded to the electrocardiographic results, using a commercially available echocardiograph (ACUSON S1000 HELX Evolution, Siemens) and a 4–7 megahertz transducer.

2.3 | Measurements

We collected data on age, sex, and hypertension status. After at least 5 min of rest, blood pressure (BP) was measured in a sitting position from non-dominant arm placed at the level of the heart, using adults' cuffs (32–42 cm) adapted to an automated sphygmomanometer OMRON HEM-7124 device (Omron Corporation). Hypertension was defined according to the 2018 ESC/ESH Guidelines for the management of arterial hypertension as office systolic BP values ≥140 mm Hg and/or diastolic BP values ≥90 mm Hg or taking antihypertensive treatment.[10] The height was measured with a locally manufactured wooden stadiometer and the weight with a clinical scale balance. The body mass index (BMI) calculated as weight (kg)/height^2 (m^2) to nearest one decimal, and BMI-based body habitus (in kg/m^2) was classified as underweight (BMI: <18.5), normal weight (BMI: 18.5–24.9), overweight (BMI: 25.0–29.9), and obesity (BMI: ≥30.0).[11] The body surface area (BSA) was calculated using the Boyd formula [0.0003207 × height (cm)$^{0.3}$ × weight (g)$^{0.7285-(0.0188 \times \log(\text{weight}))}$] to nearest two decimals.[12]

Left ventricular (LV) measurements were done on parasternal long axis 2-D guided M-mode using the American Society of Echocardiography and the European Association of Cardiovascular Imaging.[13] The Devereux formula was used for the estimation of left ventricular mass (LVM).[14] Left ventricular hypertrophy was defined as indexed LVM (LVM per m^2 of BSA) ≥115 g/m^2 in men and indexed LVM ≥ 95 g/m^2 in women.[15] The relative wall thickness (RWT) was calculated as (2 × posterior wall thickness)/(LV internal diameter at end-diastole).[13] The cutoff 0.42 was used to define the LV geometry as normal (normal LVM and RWT ≤ 0.42), concentric remodeling (normal LVM and RWT > 0.42), eccentric LVH (LVH and RWT ≤ 0.42), and concentric LVH (LVH and RWT > 0.42).[13]

The ECG was printed on a standard graph paper and interpreted (including the measurements) by a final year cardiology trainee (Faculty of Medicine and Biomedical Sciences). Voltage amplitude was measured to the nearest 0.05 mV using a ruler, with 10 mm corresponding to 1 mV. Time was measured to the nearest 0.02 s. Electrocardiographic LVH was defined as

- Sokolow-Lyon: SV1+ RV5 or RV6 ≥ 3.5 mV
- Cornell voltage index: RaVL+SV3 > 2.8 mV in men and 2.0 mV in women
- Cornell product: (RaVL+SV3) × QRSd ≥ 0.244 mV
- Peguero Lo-Presti: SDeepest+ SV4 ≥ 2.8 mV in men and 2.3 mV in women

2.4 | Statistical analysis

Data were analyzed using IBM SPSS Statistics version 26.0 for Windows. Continuous variables were described using their means and standard deviations (SD), and categorical variables using their frequencies and percentages. The comparison between males and females was done using 2-way ANOVA for continuous variables, and the chi-square test or its equivalent for categorical variables.

Sensitivity and specificity of each electrocardiographic criterion were calculated using 2 × 2 tables, with echocardiographic LVH as the reference standard. Receiver operator characteristic (ROC) analysis was performed to estimate the performance of the electrocardiographic criteria. A head-to-head comparison of electrocardiographic criteria was done based on paired-sample area difference under the receiver operatic characteristic (ROC) curves. Factors influencing agreement between echocardiography and ECG for the diagnosis of LVH were explored for each ECG criteria using binary logistic regression analysis. An ECG criterion was considered in agreement with echocardiography if it was able to appropriately identify a participant with LVH (true positive) and without LVH (true negative). The multivariable model included age, sex, hypertension, and obesity status. A $p < .05$ was considered statistically significant.

2.5 | Ethical considerations

The study was granted ethical approval by the Institutional Review Board of the Faculty of Medicine and Biomedical Sciences, University of Yaoundé I. It was performed in accordance with the Helsinki Declaration. Written informed consent was obtained from all the participants.

3 | RESULTS

3.1 | General characteristics of the study population

We included 238 participants aged 18–88 years, with a mean age of 58 (SD 13.3) years. There were 53.2% ($n = 129$) women. The clinical, electrocardiographic, and echocardiographic characteristics of the participants are summarized in Table 1. Most patients had hypertension (88.7%, $n = 211$) and were overweight (39.9%, $n = 95$) or obese (35.3%, $n = 84$), with no difference between males and females (Table 2).

3.2 | Proportions of participants with left ventricular hypertrophy

On echocardiography, 45.3% ($n = 108$) of participants had LVH (Table 3). The majority of participants with LVH had an eccentric

TABLE 1 Clinical, electrocardiographic, and echocardiographic characteristics

Variables	Females ($n = 129$) Mean	SD	Males ($n = 109$) Mean	SD	Total ($n = 238$) Mean	SD	p value
Age (years)	57.8	15.2	57.6	10.7	57.7	13.3	.921
Heart rate	81.8	18.2	81.6	17.9	81.7	18.1	.953
SBP (mm Hg)	159.8	30.1	147.8	28.7	154.3	30.0	.02
DBP (mm Hg)	95.1	16.5	95.3	16.7	95.2	16.5	.945
BMI	29.4	5.7	27.8	5.4	28.6	5.6	.025
Height (cm)	164.0	6.2	172.0	7.1	67.7	7.7	<.001
Weight (kg)	79.4	17.1	82.1	16.3	80.6	16.7	.219
BSA (m^2)	1.93	0.24	2.00	0.22	1.96	0.23	.032
QRS duration (ms)	88.3	9.4	91.1	10.1	89.6	9.8	.027
SD+SV4 (mV)	2.52	1.41	2.79	1.38	2.64	1.40	.144
RaVL+SV3 (mV)	2.26	1.13	2.30	1.10	2.28	1.11	.787
RaVL+SV3*QRS	269.3	106.7	217.7	112.3	245.6	112.1	<.001
SV1+RV5 o rV6 (mV)	3.23	1.18	2.95	1.29	3.10	1.24	.083
LVEF (%)	65.2	12.7	64.2	15.1	64.7	13.9	.580
LV weight (g)	183.1	76.3	211.5	64.4	196.1	72.3	.002
LV weight indexed (g/m^2)	99.3	43.8	108.3	31.9	103.4	39.0	.077
LVEDD (mm)	52.0	7.8	54.6	8.8	53.2	8.3	.017
LVEDD indexed (mm/m^2)	27.2	5.2	27.6	5.0	27.4	5.1	.614
LVESD (mm)	33.2	10.0	35.0	11.3	34.0	10.6	.177
LVESD indexed (mm/m^2)	17.5	6.2	17.7	5.9	17.6	6.0	.756

Abbreviations: BMI, body mass index; BSA, body surface area; DBP, diastolic blood pressure; LV, left ventricular; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; SBP, systolic blood pressure; SD, standard deviation.

TABLE 2 Distribution of participants according to hypertension status and BMI category, by sex

Variables	Females (n = 129) N (%)	Males (n = 109) N (%)	Total (n = 238) N (%)	p value
Hypertension				
No	12 (9.3%)	15 (13.8%)	27 (11.3%)	.310
Yes	117 (90.7%)	94 (86.2%)	211 (88.7%)	
BMI category				
Underweight	0 (0.0%)	2 (1.8%)	2 (0.8%)	.083
Normal	25 (19.4%)	32 (29.4)	57 (24.0%)	
Overweight	55 (42.6%)	40 (36.7%)	95 (39.9%)	
Obese	49 (38.0%)	35 (32.1%)	84 (35.3%)	

Abbreviation: BMI, body mass index.

TABLE 3 Distribution of participants by the presence of electrocardiographic or echocardiographic left ventricular hypertrophy, by sex

Variables	Females (n = 129) N (%)	Males (n = 109) N (%)	Total (n = 238) N (%)	p value
LVH by echo				
No	67 (51.9%)	63 (57.8%)	130 (54.7%)	.433
Yes	62 (48.1%)	46 (42.2%)	108 (45.3%)	
Echo LVH type				
Concentric	15 (24.6%)	10 (21.7%)	25 (23.4%)	.693
Eccentric	46 (75.4%)	36 (78.3%)	82 (76.6%)	
LVH by Cornell				
No	65 (50.4%)	77 (70.6%)	142 (59.7%)	.002
Yes	64 (49.6%)	32 (29.4%)	96 (40.3%)	
LVH by Cornell product				
No	60 (46.5%)	75 (68.8%)	135 (56.7%)	.001
Yes	69 (53.5%)	34 (31.2%)	103 (43.3%)	
LVH by Sokolow-Lyon				
No	82 (63.6%)	81 (74.3%)	163 (68.8%)	.094
Yes	47 (36.4%)	28 (25.7%)	75 (31.2%)	
LVH by Peguero-Lo Presti				
No	75 (58.1%)	60 (55.0%)	135 (56.7%)	.694
Yes	54 (41.9%)	49 (45.0%)	103 (43.3%)	

Abbreviation: LVH, left ventricular hypertrophy.

pattern (79.6%, n = 82). Electrocardiographic LVH was found in 40.3% (n = 96) of participants according to Cornell, 43.3% (n = 103) according to the Cornell product, 31.2% (n = 75) according to Sokolow-Lyon, and 43.3% (n = 103) based on Peguero-Lo Presti. Females had much higher frequencies of LVH based on Cornell (49.6% vs 29.4%; p = .002) and the Cornell product (53.5% vs 31.2%; p = .001). A similar trend was observed for Sokolow-Lyon (p = .094), whereas there was no sex difference for Peguero-Lo Presti (p = .694).

3.3 | Accuracy of electrocardiographic criteria for detecting left ventricular hypertrophy

In the overall population, the Cornell product had the highest sensitivity (67.29%), whereas Sokolow-Lyon had the lowest (48.14%). Cornell and Peguero-Lo Presti had the same sensitivity (63.89%) (Table 4). Peguero-Lo Presti had the lowest specificity (73.84%). There was no significant difference in the area under the curve (AUC) between the Peguero-Lo Presti (AUC = 0.689) and the Sokolow-Lyon (AUC = 0.652; p = .297), the Cornell (AUC = 0.716; p = .298), and the Cornell product (AUC = 0.714; p = .408) (Table 5). In males, Peguero-Lo Presti (AUC = 0.713) had a significantly higher overall accuracy (p = .003) compared to Sokolow-Lyon (AUC = 0.560); but its accuracy was not significantly different from that of the Cornell (AUC = 0.773; p = .103) and the Cornell product (AUC = 0.776; p = .129). In females, no significant difference was observed in the accuracy of Peguero-Lo Presti (AUC = 0.672) compared to Cornell (AUC = 0.659; p = .713), the Cornell product (AUC = 0.653; p = .656), and Sokolow-Lyon (AUC = 0.724; p = .245).

As shown in Figure 1, when considering indexes without applying cutoffs, SD+SV4 (Peguero-Lo Presti) showed a higher association with echocardiographic LVH compared to SV1+RV5 or RV6 (Sokolow-Lyon) [AUC 0.744 vs 0.626; p = .004], but there was no significant difference with RaVL+SV3 (Cornell, AUC = 0.758; p = .512) and (RaVL+SV3) × QRS (Cornell product, AUC = 0.777; p = .218).

Factors influencing agreement between ECG criteria and echocardiography in the detection of LVH included hypertension for Peguero-Lo Presti (adjusted odds ratio [aOR] 0.24, 95% confidence interval [CI]: 0.07–0.85; p = .027), and male sex for Sokolow-Lyon (aOR 0.57, 95% CI: 0.33–0.99; p = .046), Cornell (aOR 1.96, 95% CI: 1.07–3.58; p = .029), and Cornell Product (aOR 2.05, 95% CI: 1.13–3.72; p = .019) (Table 6).

4 | DISCUSSION

This study aimed to compare the diagnostic accuracy of the Peguero Lo-Presti criterion with the classic Cornell and Sokolow-Lyon

TABLE 4 Measures of accuracy for each left ventricular hypertrophy electrocardiography criteria, by sex and in obese population

Population	Criteria	Sensitivity	Specificity	PPV	NPV	AUC
Overall (n = 238)	Cornell	63.89	79.23	71.88	72.53	0.716
	Cornell product	67.29	75.97	69.90	73.68	0.714
	Sokolow-Lyon	48.14	82.31	69.33	65.34	0.652
	Peguero-Lo Presti	63.89	73.84	67.00	71.11	0.689
Males (n = 109)	Cornell	60.87	93.65	87.50	76.62	0.773
	Cornell product	63.04	92.06	85.29	77.33	0.776
	Sokolow-Lyon	32.61	79.37	53.57	61.73	0.560
	Peguero-Lo Presti	69.57	73.02	65.31	76.67	0.713
Females (n = 129)	Cornell	66.13	65.67	64.06	67.69	0.659
	Cornell product	69.35	61.19	62.32	68.33	0.653
	Sokolow-Lyon	59.68	85.07	78.72	69.51	0.724
	Peguero-Lo Presti	59.68	74.63	68.51	66.67	0.672

Abbreviations: AUC, area under the curve; NPV, negative predictive value; PPV, positive predictive value.

TABLE 5 Pairwise comparison of areas under the receiver operatic characteristic (ROC) curve between electrocardiographic criteria

| Criterion 1	Criterion 2	Overall (n = 238)		Males (n = 109)		Females (n = 129)	
		AUC difference	p value	AUC difference	p value	AUC difference	p value
Peguero-Lo Presti	Sokolow-Lyon	0.036	.297	0.153	.003	−0.052	.245
Peguero-Lo Presti	Cornell product	−0.025	.408	−0.063	.129	0.019	.656
Peguero-Lo Presti	Cornell	−0.027	.298	−0.060	.103	0.013	.713
Cornell	Sokolow-Lyon	0.063	.075	0.213	<.0001	−0.065	.160
Cornell	Cornell product	0.001	.946	−0.003	.923	0.006	.845
Cornell product	Sokolow-Lyon	0.062	.088	0.216	<.0001	−0.071	.140

Abbreviation: AUC, area under the curve.
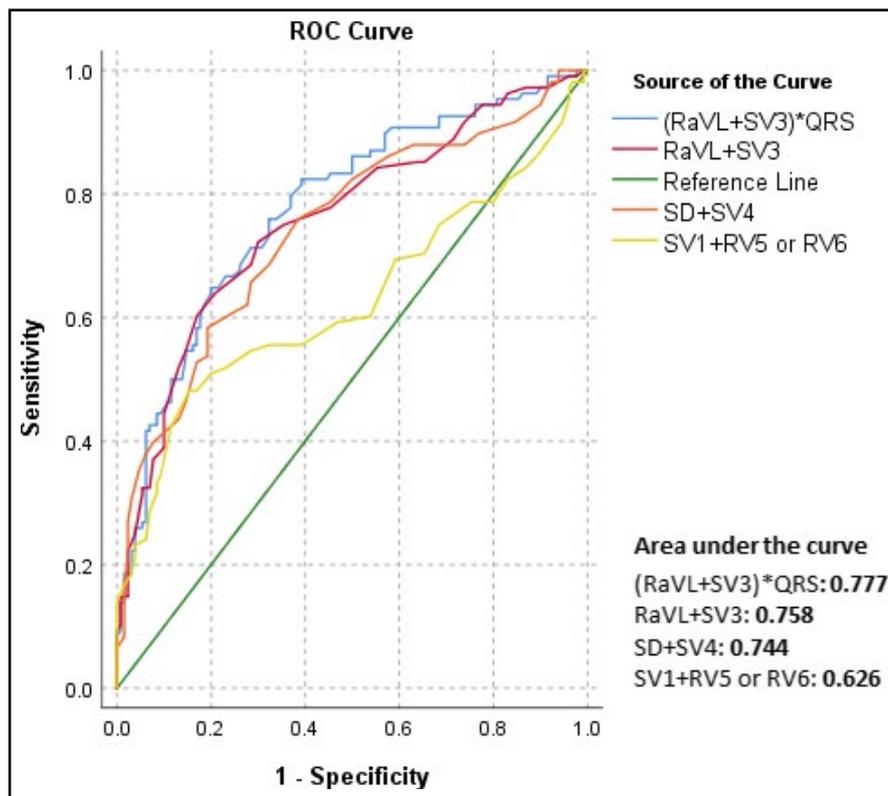
FIGURE 1 Diagnostic performance of various electrocardiographic indexes by receiver operatic characteristic (ROC) curve

TABLE 6 Factors influencing agreement between electrocardiographic criteria and echocardiography in left ventricular hypertrophy detection

Variables	Adjusted odds ratio	95% CI	p value
Peguero-Lo Presti			
Age	0.99	0.97–1.01	.428
Male sex	1.06	0.61–1.86	.828
Hypertension	0.24	0.07–0.85	.027
Obesity	1.07	0.59–1.94	.823
Sokolow-Lyon			
Age	1.01	0.99–1.03	.464
Male sex	0.57	0.33–0.99	.046
Hypertension	0.54	0.20–1.44	.216
Obesity	0.85	0.47–1.52	.575
Cornell			
Age	0.99	0.97–1.01	.371
Male sex	1.96	1.07–3.58	.029
Hypertension	0.29	0.08–1.04	.057
Obesity	1.38	0.73–2.60	.324
Cornell product			
Age	0.98	0.96–1.01	.130
Male sex	2.05	1.13–3.72	.019
Hypertension	0.48	0.15–1.53	.203
Obesity	0.85	0.46–1.58	.607

Note: All exploratory variables included in the multivariable binary logistic regression model. Female sex, no hypertension, and normal weight are references categories.

criteria, and the less commonly used Cornell product criterion, for the electrocardiographic detection of LVH. Based on the AUC, the overall accuracy of the Peguero-Lo Presti was not significantly different from that of the Sokolow-Lyon, Cornell, and Cornell product criteria. Hypertension and gender influenced the agreement between ECG criteria and echocardiography in the detection of LVH, age and obesity did not.

The conception of the Peguero-Lo Presti index was based on a new cardiac electrophysiological paradigm. In contrast with several previous criteria that are based on the measurement of the highest amplitude of the R wave in various leads alone or combined with other components,[4] Peguero et al hypothesized that the S wave might better reflect the activation of the myocardial and epicardial left ventricular free wall which occurs after 50 msec of the left ventricular depolarization.[5] Therefore, changes in left ventricular mass might be better detected by electrical cardiac changes shown by the S wave. Indeed, in their paper presenting the Peguero-Lo Presti criterion, they showed that the S waves of the precordial and limb leads had a better association with an increased left ventricular mass as compared to the R waves.[5] Furthermore, because the variations in the distance between the heart and the torsum, the position of the surface electrode and the body habitus contribute to poor electrocardiographic detection and reproducibility of changes in cardiac

structure, they considered that measurement of the highest voltage in any single lead rather than a fixed single lead would improve accuracy.[5] They suggested that this was the main reason why their criterion, which focuses on the S wave with a flexible lead selection, had better performance in the validation cohort compared to the Sokolow-Lyon and Cornell which include an amplitude of both R and S waves in fixed leads.[5]

Several studies have shown a superiority of the Peguero-Lo Presti criterion over the Cornell and Sokolow-Lyon criteria. Indeed, in a recent systematic review and meta-analysis, Peguero-Lo Presti had a better pooled diagnostic performance based on ROC analysis, with an AUC of 0.83 compared to 0.72 and 0.62 for Cornell and Sokolow, respectively.[6] However, some other studies showed some discrepancies as our study does. In a Turkish population, Keskin et al found that although the Peguero-Lo Presti criterion had higher sensitivity than the Cornell criterion (17.5% vs 9.7%), it had lower specificity (94.5% vs 98.2%) and slightly lower overall performance based on the AUC (0.64 vs 0.67).[16] Similar findings were reported by Sun et al in a large Asian population (n = 10 614).[7] Several factors could explain these differences. First, the landmark study by Peguero et al was retrospective and had smaller sample size (94 participants in the derivation cohort and 122 in the validation cohort). Clinical and echocardiographic characteristics of the study populations could have contributed to these inconsistent findings. The body habitus which is known to influence the test performance of the electrocardiography was not reported in the study by Peguero et al.[17] It is unknown whether adjustment for BMI would have a significant influence on the comparative performance of these criteria. However, obesity did not have significant influence on the agreement between ECG criteria and echocardiography in the detection of LVH in the current study. The unusual high proportion of eccentric LVH in our population (79.6% vs 25.5% in the study by Peguero et al) could also be a reason for discordance.[5] Indeed, there are data showing that eccentric LVH is less accurately detected by electrocardiography compared to concentric LVH.[18] Furthermore, race is an important factor to consider. Our study along with few others suggests that the performance of the Peguero-Lo Presti criterion might vary across racial and potentially ethnic groups.[7,8,16]

Overall, our findings suggest that the Peguero-Lo Presti criterion with its current cutoffs is not significantly better than older criteria such as Cornell, Cornell product, or Sokolow-Lyon for electrocardiographic detection of LVH in black Africans. However, our study is limited by its relatively small sample size and the fact that the participants represented a selected group recruited in hospital with a large proportion having hypertension and therefore, not representative of the general population. Hence, further studies on larger and minimally selected populations need to be conducted in several African settings to substantiate our findings. Our study shows similar sensitivity of Peguero-Lo Presti compared to Cornell. The other studies that showed lower AUC of Peguero-Lo Presti, however, reported that it had a higher sensitivity compared to Cornell and Sokolow-Lyon.[7,16] In fact, the sensitivity is the most important parameter to consider when looking at

a screening test. Criteria with high sensitivity should be given priority for routine screening, as they are more likely to identify the maximum of individuals with LVH (true positive) who need confirmation of the diagnosis with cardiac imaging, usually echocardiography. Considering the higher sensitivity of Peguero-Lo Presti in most studies, this criterion might be a more appropriate electrocardiographic screening tool compared to the usual Cornell and Sokolow-Lyon criteria. However, further improvements might be needed, including correction for extracardiac factors such as ethnicity, age, and most importantly adiposity, considering the high prevalence of overweight and obesity in the general population and particularly in patients needing screening for LVH.[19] Future studies should also explore the impact of valvular heart disease on the diagnostic performance of the Peguero-Lo Presti criterion, and the ability of this criteria to predict adverse outcomes. For instance, Peguero-Lo Presti LVH was shown to be an independent predictor of all-cause mortality in a group of patients with aortic stenosis.[20]

5 | CONCLUSION

Overall, our study shows that the accuracy of the Peguero-Lo Presti criterion was not significant different from that of the Cornell, Cornell Product, and Sokolow-Lyon criteria. In males, Peguero-Lo Presti was better than Sokolow-Lyon. The agreement between ECG criteria and echocardiography in the detection of LVH was influenced by hypertension (for Peguero-Lo Presti) and gender (for Sokolow Lyon, Cornell, and the Cornell product), but not by age and obesity status. Larger studies are needed to verify these findings, and more importantly, to assess whether adjustments for race, sex, age, and adiposity could improve the performance of the Peguero-Lo Presti criterion, especially in black Africans.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

AUTHOR CONTRIBUTIONS

JJN, UFN, JB, and AM involved in conception and design. UFN, MM, and CSNM involved in data collection. JJN and UFN involved in data analysis and interpretation, manuscript drafting. UFN, JJN, MM, CSNM, JB, and AM involved in manuscript revision. UFN, JJN, MM, CSNM, JB, AM, and SK involved in manuscript approval for submission.

DATA AVAILABILITY STATEMENT

Data are available from the corresponding author upon reasonable request.

ORCID

Ulrich Flore Nyaga 🄳 https://orcid.org/0000-0002-4082-9580
Jean Jacques Noubiap 🄳 https://orcid.org/0000-0002-7722-9757

REFERENCES

1. Bauml MA, Underwood DA. Left ventricular hypertrophy: an overlooked cardiovascular risk factor. *Cleve Clin J Med.* 2010;77(6):381-387.
2. Bluemke DA, Kronmal RA, Lima JA, et al. The relationship of left ventricular mass and geometry to incident cardiovascular events: the MESA (Multi-Ethnic Study of Atherosclerosis) study. *J Am Coll Cardiol.* 2008;52(25):2148-2155.
3. Verdecchia P, Angeli F, Borgioni C, et al. Changes in cardiovascular risk by reduction of left ventricular mass in hypertension: a meta-analysis. *Am J Hypertens.* 2003;16(11 Pt 1):895-899.
4. Hancock EW, Deal BJ, Mirvis DM, et al. AHA/ACCF/HRS recommendations for the standardization and interpretation of the electrocardiogram: part V: electrocardiogram changes associated with cardiac chamber hypertrophy: a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society. Endorsed by the International Society for Computerized Electrocardiology. *J Am Coll Cardiol.* 2009;53(11):992-1002.
5. Peguero JG, Lo Presti S, Perez J, Issa O, Brenes JC, Tolentino A. Electrocardiographic criteria for the diagnosis of left ventricular hypertrophy. *J Am Coll Cardiol.* 2017;69(13):1694-1703.
6. Noubiap JJ, Agbaedeng TA, Nyaga UF, Nkoke C, Jingi AM. A meta-analytic evaluation of the diagnostic accuracy of the electrocardiographic Peguero-Lo Presti criterion for left ventricular hypertrophy. *J Clin Hypertens.* 2020;22(7):1145-1153.
7. Sun GZ, Wang HY, Ye N, Sun YX. Assessment of novel peguero-lo presti electrocardiographic left ventricular hypertrophy criteria in a large asian population: newer may not be better. *Can J Cardiol.* 2018;34(9):1153-1157.
8. Jingi AM, Noubiap JJ, Kamdem P, Kingue S. Determinants and improvement of electrocardiographic diagnosis of left ventricular hypertrophy in a black African population. *PLoS One.* 2014;9(5):e96783.
9. Louis FJ, Mpoudi-Ngole E, Leloup M, Louis JP. Cameroon, Africa in miniature: health situation in 1995. *Med Trop.* 1995;55(4):313-322.
10. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J.* 2018;39(33):3021-3104.
11. Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. Executive summary of the clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. *Arch Intern Med.* 1998;158(17):1855-1867.
12. Boyd E. *The growth of the surface area of the human body.* Minnesota: Univ Minnesota Press; 1935: 145.
13. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *J Am Soc Echocardiogr.* 2015;28(1):1-39 e14.
14. Devereux RB, Alonso DR, Lutas EM, et al. Echocardiographic assessment of left ventricular hypertrophy: comparison to necropsy findings. *Am J Cardiol.* 1986;57(6):450-458.
15. Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. *J Am Soc Echocardiogr.* 2005;18(12):1440-1463.
16. Keskin K, Ser OS, Dogan GM, et al. Assessment of a new electrocardiographic criterion for the diagnosis of left ventricle hypertrophy: a prospective validation study. *North Clin Istanb.* 2020;7(3):231-236.

17. Okin PM, Roman MJ, Devereux RB, Kligfield P. ECG identification of left ventricular hypertrophy. Relationship of test performance to body habitus. *J Electrocardiol*. 1996;29(Suppl):256-261.

18. Tomita S, Ueno H, Takata M, Yasumoto K, Tomoda F, Inoue H. Relationship between electrocardiographic voltage and geometric patterns of left ventricular hypertrophy in patients with essential hypertension. *Hypertens Res*. 1998;21(4):259-266.

19. Noubiap JJ, Jingi AM. Adjustments of electrocardiographic criteria for the diagnosis of left ventricular hypertrophy. *J Am Coll Cardiol*. 2017;70(5):686-687.

20. Ramchand J, Sampaio Rodrigues T, Kearney LG, Patel SK, Srivastava PM, Burrell LM. The Peguero-Lo presti electrocardiographic criteria predict all-cause mortality in patients with aortic stenosis. *J Am Coll Cardiol*. 2017;70(14):1831-1832.