Original Article

Influence of Bust Size and Waist Circumference on Electrocardiographic Left Ventricular Voltage Index in Blacks Africans

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Abstract

Background: Several studies have investigated on relationship between anthropometric characteristics and electrocardiographic left ventricular mass (LVM). These studies, performed mainly in Caucasians, have mostly focused on influence of body mass index on left ventricular voltage indices (LVVI), and rarely on bust size and/ or waist circumference.

Aim: To determine influence of bust size and waist circumference on LVVI in healthy sedentary people of black African origin.

Method: Experimental, prospective, cross-sectional descriptive study including 66 volunteers (20 women) aged 18 to 35 years. They were received in morning on empty stomach. Bust size and waist circumference were measured with tape measure. Standard electrocardiogram was performed at rest. R and S wave amplitude and QRS complex duration were measured. Sokolow-Lyon, R in aVL, Cornell and Cornell product indexes were calculated. Correlation was sought between each LVVI and anthropometric characteristics studied.

Results: Bust size and waist circumference were positively correlated with LVVI. Correlation with bust size was statistically significant for all LVVI except for R in aVL index, while for waist circumference it was only significant with R in aVL index.

Conclusion: This study confirms relationship between anthropometric characteristics and LVVI. Therefore, interpretation of LVM anomalies from LVVI should also take into consideration morphotype of each individual.

Key words: bust size, waist circumference, resting electrocardiogram, left ventricular voltage index.

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Introduction

For electrocardiographic diagnosis of abnormal left ventricular mass (LVM), several left ventricular voltage index (LVVI) have been proposed[1]. These LVVI, obtained from the amplitude and duration of QRS complexes on resting electrocardiogram (ECG), study heart in various plans from different electrocardiographic leads[2]. Among available LVVI, four are most widely used: Sokolow-Lyon index, R in a VL index, Cornell index and Cornell product[3]. In practice, LVVI is first approach for diagnosing anomalies of LVM. However, compared with echocardiography, which is gold standard for direct assessment of LVM anomalies[4,5], their sensitivity is low, ranging from 5% to 51%[6]. Research to improving diagnostic sensitivity of LVVI has been subject of several studies[7-11]. They investigated relationships between LVVI and influencing factors such as age, gender, race and anthropometric characteristics. Among anthropometric characteristics, various works[7-9,12] have investigated the relationship between body mass index (BMI) and LVVI in overweight or obese subjects. These studies have been performed mainly in caucasian populations, and rarely in black populations. However, black populations are considered to have specific electrocardiographic characteristics. For example, QRS complexes used to determine some LVVI have greater amplitude[13] and shorter duration[14] in black subjects compared with white subjects. In addition, very little study has been done on influence of body surface area on LVVI[15], and there is almost no study on influence of bust size and/or waist circumference on LVVI. The aim of this study was to determine influence of bust size and waist circumference on most commonly used LVVI in healthy sedentary people of black African origin.

Material and Methods

Study population

The target population consisted of student volunteers from Félix Houphouët-Boigny University (FHBU) in Abidjan (Côte d'Ivoire), who were recruited orally in amphitheaters after receiving information on purpose and methodology of study. Subject inclusion for study was based on age between 18 and 25 years, black African origin, Ricci and Gagnon score of less than 35 (inactive and not very active subjects) and body mass index (BMI) of less than 30 kilograms per square meter. Subjects with any of following criteria were not included in study: a personal antecedent of major cardiovascular risk factors (hypertension, diabetes, dyslipidemia and smoking), cardiovascular or bronchopulmonary symptoms or pathology, hemoglobinopathy, recent (less than a week) or current infection, current cardiovascular drug therapy. A family history of sudden death or genetic heart disease were additional reasons for non-inclusion. During study, absence or non-acceptance of protocol by subject and ECG anomalies such as bundle-branch block or right ventricular hypertrophy were exclusion criteria.The minimal study sample size (N) was calculated at 47 subjects from the size formula ($N = [(Z\alpha+Z\beta)/C]2 + 3$) based on detection of correlation coefficient of 0.4[16]. According to selection criteria, 66 of 73 volunteers, including 20 women, constituted our study population.

Study protocol

This was experimental, prospective, cross-sectional, descriptive study conducted in physiology and functional explorations laboratory (PFEL), FHBU. The study was conducted between January 2021 and April 2021. Subjects included were convoked to PFEL in morning on empty stomach, following a set program. Study protocol consisted of three steps: interrogation, anthropometric measurements and ECG recording.

Short interrogation looked for major stress, functional sign that had occurred within 48 hours and medication taken within 72 hours prior to convocation.

Weight was measured in unshod subject with empty pockets. Height was measured with feet joined, back to wall and head in Frankfurt direction[17]. Bust size and waist circumference were measured using a tape measure. Bust size was measured with subject standing upright, with back straight and torso straight. Tape measure was positioned horizontally 5 cm below armpit and on nipple line in men, and under the breast in women, to ensure uniformity of measurement. Waist circumference was measured on horizontal surface. Subject stood comfortably, with weight evenly distributed between the two feet, slightly apart. Tape measure was placed around the waist, equidistant between last ribs and iliac crest. It was adjusted so as not to compress underlying soft tissues. Waist circumference was measured at end of normal expiration[18]. After these measurements, subjects were installed in quiet, air-conditioned room (temperature between 22 and 24°C) for recording of standard 12-lead ECG, in 3-channel format and in medium-length tracing. The MindrayBeneHeart R12 was used. ECGs were performed by two technicians specializing in cardiorespiratory function tests. Subject was positioned supine, eyes closed, palms flat on the bed, wrists and ankles free of metal accessories (jewelry and belts), pockets empty, chest unclothed. Electrodes were positioned according to AHA/ACC/HRS recommendations[1,19]. After five minutes' rest, ECG were recorded at speed of 25 mm/s and voltage of 10 mm/mV with active filter[1,19]. Recording was done in apnea to avoid influence of rib cage movements on electrocardiographic wave amplitude[20].All ECG lines contained at least five QRS complexes per lead. Two readings of each printed ECG were taken by two cardiologists. A third reading was taken by third cardiologist when there was difference of more than one millimeter in amplitude and more than 0.002 seconds in duration between first two readings.

Parameters studied

Study population was divided by gender. BMI was calculated using formula BMI = Weight/(Height)² in kg/m². In overall, female and male population, averages for age, BMI, bust size and waist circumference were calculated and compared.

On ECG, QRS complex, electrical signal translating ventricular activation, has been studied. By convention, first negative deflection is called Q wave, first positive deflection is R wave, negativity following R wave, is called S wave[6].R and S wave amplitudes were measured in all leads except aVR, from baseline to wave peak. In one derivation, R-wave amplitude value chosen was average of amplitudes of all the R-waves in said derivation. The same was done for S-waves in each lead. Duration of QRS complex was determined in lead V5, from start of 1st deflection of isoelectric line occurring after P wave to J point. QRS complex duration used was average of QRS durations of said lead.

For this work, four most commonly used LVVI were calculated from R and S wave amplitudes and QRS complex duration[3].Sokolow-Lyon index, determined from S and R amplitude waves, respectively in leads V1 and V5 (SV1 + RV5) has been said to be normal for a value of less than 45 millimeters (mm) in subjects with an age of less than 40 years[6]. R in aVL index, which corresponds to amplitude of R wave in aVL lead, was rated normal if value was less than 11 mm. Cornell index, determined from amplitude of S and R waves, respectively in aVL and V3 leads (RaVL + SV3).This index was normal if value was less than or equal to 20 mm in women and less than or equal to 28 mm in men. Cornell product, which corresponds to product Cornell index by QRS duration [(RaVL + SV3) x QRS duration] whose normal value was less than or equal to 2440 mm.ms[1,3]. Averages for each LVVI were calculated in overall population and for each gender on basis individual values. These averages were compared with each other. A correlation was researched between each LVVI and bust size and waist circumference in overall population.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics software. Population means for age, anthropometric and electrocardiographic characteristics were compared in men's and women's groups, using Student's t-test for independent samples. Data were described by means and p-value. Pearson's correlation coefficient was used to verify existence of linear relationship between bust size and waist circumference and LVVI. Analyses were conducted for an acceptable type 1 error set at 0.05.

Ethical considerations

This study was followed the guidelines of Helsenki Declaration. The problematics, purpose, objectives and protocol of the study were explained to the subjects. Written informed consent was obtained from all study participating. The barrier precautions for Covid-19 were respected.

Results

Age and anthropometric characteristics of the study population are listed in Table 1. Only bust size was significantly different between men and women. Mean values of left ventricular voltages index (LVVI) calculated in overall population, men and women were normal (Table 2). Mean LVVI values for men were significantly higher than women, except for the R index in aVL. Table 3 shows correlations between anthropometric characteristics studied and LVVI. LVVI were positively correlated with bust size and waist circumference. Correlation with bust size was statistically significant with all LVVI except with R in aVL index, whereas with waist circumference it was significant only with R in aVL index.

Table 1: Age and anthropometric characteristics of study population.

	All (n=66)	Men (n=46)	Women (n=20)	p
Age (years)	22,9±3,3	23,1±3,3	22,5±3,3	0,50
BMI (kg/m^2)	22±2,6	21,8±2,2	22,4±3,6	0,50
Bust size (cm)	76,7±6,3	79,6±5,1	69,9±4,1	0,00
Waist circumference (cm)	72,6±5,9	73,4±5,1	70,88±7,5	0,19

n = population size; kg/m^2 = kilogram per square meter;
m = meter; BMI = body mass index; p = test significance.

Table 2: Electrocardiographic characteristics of study population.

LVVI	All (n=66)	Men (n=46)	Women (n=20)	p
Sokolow-Lyon	31,9±10,6	35,2±10,3	24,2±6,6	0,00
R in aVL	2,6±1,9	2,7±2,1	2,3±1,6	0,46
Cornell	12,3±6,9	14,5±6,8	7,1±3,8	0,00
Cornell Product	1099,8±634,3	1320,8±614,9	591,47±301,4	0,00

n = population size; LVVI = left ventricular voltages index, p = test significance.

Table 3: Correlations between anthropometric characteristics studied and LVVI.

LVVI	Bust size (cm)		Waist circumference (cm)	
	r	p	r	p
Sokolow-Lyon	0,282	0,022	0,116	0,355
R in aVL	0,182	0,145	0,362	0,003
Cornell	0,327	0,007	0,171	0,169
Cornell Product	0,360	0,003	0,203	0,101

LVVI = left ventricular voltages index; cm = centimeter;
r = correlation coefficient; p = correlation significance.

Discussion

The aim of this work was to determine influence of bust size and waist circumference on four most commonly used left ventricular voltage index (LVVI) in healthy, sedentary subjects of black African origin. In our sample of black African subjects, bust size and waist circumference was positively correlated with LVVI. Correlation with bust size was statistically significant with all LVVI except with R in aVL index, whereas with waist circumference it was significant only with R in aVL index.

Influence of factors such as age, sex, race and anthropometric characteristics on left ventricular mass (LVM) is known anatomically[21,22], echocardiographically[4,5,23,24] and electrocardiographically[7-9,12]. In previous study[15] we didn't find any correlation between body surface area and four most commonly used LVVI. Among studies that have examined relationship between anthropometric characteristics and LVVI, several have concerned body mass index (BMI). Indeed, Okin et al.[25] reported significantly higher Cornell product in overweight and obese subjects compared to normal BMI subjects. Abacherli et al.[9] and Hassing et al.[12] showed negative correlation between BMI and Sokolow-Lyon index in their studies of Caucasian youth. Courand et al.[10] reported positive correlations between R aVL index and BMI in obese subjects. All these data illustrate influence of body morphology on electrocardiographic waves, and are in line with results of present study. Bust refers to the part of body between hips and neck[26].During ECG recording, precordial electrodes are positioned on limbs and chest according to international recommendations[1,19]. Position of electrodes could partly explain significant correlation of LVVI integrating in their estimation leads obtained from electrodes positioned on chest, therefore close to the heart. In fact, Sokolow-Lyon index and R in aVL index explore left ventricular muscle mass in horizontal and frontal plans respectively[6] using electrodes positioned on bust and limbs. These LVVI were proposed in 1949 for electrocardiographic left ventricular hypertrophy diagnosis[1]. Their sensitivity is low, at 5%[27] and approaching 20%[10] respectively. To improve performance and diagnostic accuracy of LVM anomalies, Cornell index has been proposed[6]. It explores heart in horizontal and frontal plans, with sensitivity ranging from 30-40%[6,28]. Further work has emphasized necessity of extending beyond simple QRS complex amplitude measurements to improve ECG performance in detecting LVM anomalies[6,10]. One approach has been to incorporate duration of QRS complex into QRS complex amplitudes[6,10]. QRS complex duration is an essential parameter for assessing intraventricular conduction and identifying LVM increase. It changes proportionally with LVM[6]. Sensitivity of Cornell product combined with Sokolow-Lyon index would be between 45 and 50%[29]. Sokolow-Lyon index, Cornell index and Cornell product, which incorporate derivations obtained from electrodes positioned on the chest, were significantly correlated with bust size in our study. The non-significance of correlation of bust size with R in aVL index could be partly attributed to small sample size of our study, but also to the fact that this lead is obtained from information provided by four limb electrodes and not from those positioned on the bust.

Waist circumference is simple measurement that reflects visceral fat. As for increase electrocardiographic LVM in prediction of cardiovascular risk[6], waist circumference would be an independent indicator of cardio-metabolic risk[30]. The non-significance of correlation of waist circumference with Sokolow-Lyon, Cornell and Cornell product indexes could also be attributed to the small size of our study sample, but also due to the fact that calculating LVVI would represent indirect approach to estimating LVM anomalies. Because of this indirect approach, ECG recordings are influenced by various factors, including heart position in mediastinum[20]. It has been described that shorter distance between anterior chest wall and middle of left ventricle would increase ECG wave amplitude[31], and inversely. Positions of ECG electrodes could therefore influence significance of these LVVI with waist circumference. Finally, while data on relationship between waist circumference and cardiovascular risk are well known in literature[30], no studies to date have investigated relationship between bust size and cardiovascular risk.

Conclusion

This study confirms relationship between anthropometric characteristics and LVVI. To our knowledge, is one of rare have investigated on influence of bust size and waist circumference on left ventricular voltage indices in healthy sedentary black African subjects. This study showed positive correlation between bust size and waist circumference with four most commonly used left ventricular voltage indexes: Sokolow-Lyon, R in aVL, Cornell and Cornell product. It confirms influence of body morphology on electrocardiographic waves. Therefore, interpretation of left ventricular mass anomalies from LVVI should also include consideration of individual morphotype. Larger sample sizes would improve significance of relationship between these two anthropometric characteristics with LVVI.

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