



Masculine and Feminine Patterns in Electrocardiogram: Sensitivity and Specificity of an Electrocardiographic Score for Sex Verification among Young Adult Nigerians

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Abstract

This study aimed to determine the sensitivity and specificity of an electrocardiographic scoring system for sex verification in young adults. Four hundred and seventy four (474) healthy young adults (294 males, 180 females). The mean (\pm SD) age, height, weight and body mass index of the participants were 23.85 ± 4.66 years, 1.68 ± 0.83 m, 66.3 ± 9.05 kg and 21.82 ± 2.80 respectively. A technician documented the sex of the participants and had their resting standard 12-lead electrocardiogram (ECG) recorded according to standard protocol. A cardiologist who was blinded to the sex of the participant utilized Ogunlade Sex Determination Electrocardiographic Score (OSDES) to determine the sex of participants. Females and males were identified by $OSDES < 7$ and ≥ 7 respectively. The sensitivity and specificity of OSDES was estimated for both sexes. Among the male population, true positives (TP), false positives (FP), false negatives (FN) and true negatives (TN) were 288, 6, 6 and 174 respectively. Among the females TP, FP, FN and TN were 174, 6, 6 and 288 respectively. Among males, the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were 97.96%, 96.67%, 97.96% and 96.67% respectively while among the females, the sensitivity, specificity, PPV and NPV were 96.67%, 97.96%, 96.67% and 97.96% respectively. This study concluded that the sensitivity and specificity of electrocardiogram in sex verification among young adults were high and that an individual's sex can be verified using a biological signal such as electrocardiogram. Moreover, delineation of ECG into masculine and feminine patterns using the electrocardiographic score is an advancement with great clinical potentials in the area of ECG interpretation.

Keywords: Sex differences, electrocardiographic score, sex verification, young adults.

Introduction

Electrocardiogram (ECG) is the graphical record of the electrical activities of the heart obtained from the body surface. It is a basic non-invasive investigation in cardiovascular medicine with great application in medical practice¹. ECG machine is a cheap, portable and harmless tool that is very useful in the assessment of cardiac electrical activities and to some extent cardiac structures. ECG was acknowledged as the most commonly conducted cardiovascular procedure in clinical practice²⁻³. Sex differences in various aspects of ECG including QRS amplitude, QT interval, heart rate and repolarization pattern had been established for decades⁴⁻⁵. Sex verification can be done prenatally or postnatally. Prenatally, sex is commonly determined non-invasively through the use of ultrasonography⁶. Postnatally, sex of an individual can be determined non-invasively through assessment of physical outlook and skull morphological traits⁷⁻⁸. The gold standard test for verification of sex is chromosomal analysis. The basis and potentials of ECG in sex verification among young adults had been established recently. ECG could be useful in sex verification among young

adults⁹. This study aimed to assess the sensitivity and specificity of an electrocardiographic scoring system in verification of sex among young adult Nigerians.

Methodology

Participant Selection: The target population was undergraduate and postgraduate students of a Tertiary Institution in Nigeria. A total of four hundred and seventy four (474) healthy young adults (294 males, 180 females) from 17 to 44 years (mean \pm SD = 23.85 ± 4.66 years) were recruited for the study. It was a cross-sectional descriptive study. This study was approved by the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife. Volunteers were selected after exclusion of systemic diseases that could adversely affect their ECG.

ECG Acquisition Protocol: The standard 12-lead ECG of each participant was obtained in supine position after about 5 minutes of rest during quiet respiration. The participants were enlightened about the protocol and their written consent

obtained. Materials like wrist watch, jewellery, mobile phones and coins were removed from the body to reduce electromagnetic interference. The limbs and chest were exposed and electrode placed according to internationally approved protocol. The chest lead recordings (V1-V6) were obtained by the attachment of six electrodes to the precordium according to the conventional methods; V1 at 4th intercostal space right sterna edge, V2 at 4th intercostal space left sternal edge, V3 at the point midway between V2 and V4, V4 at 5th intercostal space left midclavicular line, V5 and V6 were placed respectively at left anterior axillary line and mid-axillary line at same horizontal line with V4. An electrode was attached to each of the limbs to record limb leads. Before acquisition of the ECG, the ECG technician entered the identification number, age, sex, weight, height and blood pressure into the electrocardiograph. Standard 12-lead ECGs were recorded by the technician at a speed of 25mm/s and calibration signal of 10mm/mV. The results were printed out.

Determination of Sex using Ogunlade Sex Determination Electrocardiographic Score (OSDES): The ECG print outs were processed with a black paper mark on the sex section. A cardiologist who was blinded to the previously recorded sex of the participant utilized OSDES to determine the sex of the participants. OSDES was derived from summation of the scores in T wave configuration in V1, ST segment in V2 or V3, QRS rotation and heart rate (table-1). Individual's total minimum and maximum scores were 4 and 12 respectively. An individual with an OSDES total score of <7 was considered a female while an individual with a score ≥ 7 was considered a male. The sex determined by OSDES was compared with the sex recorded by the ECG technician. The tests of validity of OSDES were obtained with the formulae: sensitivity = TP/TP+FN, specificity = TN/FP+FN, positive predictive value (PPV) = TP/TP+FP, negative predictive value (NPV) = TN/FN+TN where TP=true positive, FN= false negative, TN=true negative and FP=false positive. TP-Sex determined by physical appearance (PA) and OSDES were positive, TN=Sex determined by OSDES and PA were negative, FP- Sex by PA was negative but sex by OSDES was positive, FN=Sex by PA was positive but sex by OSDES was negative. All the results were expressed in percentage.

Results and Discussion

Four hundred and seventy four (474) young adults (62.03% were males and 37.97% were females) participated in the study. The mean (±SD) height, weight and body mass index of the participants were 1.68 ± 0.83m, 66.3 ± 9.05kg and 21.82 ± 2.80 respectively. The masculine ECG pattern was characterized by upright T wave in precordial leads especially V1, ST segment elevation ≥ 2mm above PR segment in V1-V4 with dominance in V2-V3, normal or clockwise QRS rotation and a lower heart rate usually < 70beats per minutes (figure-1). The feminine ECG pattern was characterized by T wave inversion in V1-V2 especially in V1, isoelectric ST segment in precordial leads especially V1-V2, anticlockwise rotation and a higher heart rate

usually >70beats per minute (figure-2). Among the male population, true positives (TP), false positives (FP), false negatives (FN) and true negatives (TN) were 288, 6, 6 and 174 respectively. Among the females TP, FP, FN and TN were 174, 6, 6 and 288 respectively. Among the 474 participants 62.03% were males while 37.97% were females). Among the males, TP = 288, FP = 6, FN = 6, TN = 174, sensitivity = 97.96% (95% CI: 95.61%-99.25%), specificity = 96.67% (95% CI: 92.89% - 98.77%), positive predictive value (PPV) = 97.96% (95% CI: 95.61% - 99.25%) and negative predictive value (NPV) = 96.67% (95% CI: 92.89% - 98.77%). Among the females, TP = 174, FP = 6, FN = 6, TN = 288, sensitivity = 96.67% (95% CI: 92.89% - 98.77%), specificity = 97.96% (95% CI: 95.61%-99.25%), PPV = 96.67% (95% CI: 92.89% - 98.77%) and NPV = 97.96% (95% CI: 95.61% - 99.25%).

Table-1
Ogunlade sex determination electrocardiographic score (OSDES)

Parameters	Criteria	Score
T wave in V1	Inversion	1
	Flattened	2
	Upright	3
ST segment in V2 or V3	Isoelectric: at 0-1mm of PR segment	1
	Depression : ≥ 2mm below PR segment	2
	Elevation : ≥ 2mm above PR segment	3
Rotation	Anticlockwise rotation	1
	Normal transition	2
	Clockwise rotation	3
Heart rate (beats per minute)	>70	1
	60-70	2
	<60	3

OSDES total ranges from 4-12, OSDES < 7 = Female, OSDES ≥ 7 = Male

Discussion: From laboratory to clinical practice, the breakthroughs in ECG had been unprecedented in medical history. William Einthoven, a Dutch physiologist opened up the field of clinical application of ECG by his publication of the first organized normal and abnormal ECG¹⁰. He described various abnormalities which include; left and right ventricular hypertrophy, left and right atrial hypertrophy, the U wave, notching of the QRS complex, ventricular premature beat,

ventricular bigeminy, atrial flutter and complete heart block¹⁰. ECG has a very wide application in the assessment of cardiac and extracardiac disorders. It had been found useful in the evaluation of chamber size abnormalities (right and left atrial abnormalities, right ventricular hypertrophy and left ventricular

hypertrophy), coronary artery disease, pericardial diseases, hypertension, cardiomyopathy, pulmonary heart disease, congenital heart diseases, genetic syndromes especially long QT syndromes, electrolyte derangement, cardiac arrhythmias, heart blocks and drug effects^{1,11-12}.



Figure-1

ECG of a 29year old Nigerian showing electrocardiographic features of male ECG pattern; upright T wave in V1(3), elevation of ST segment in V2 or V3(3), normal transition(2) and heart rate between 60-70beats per minute(2). Total OSDES =10



Figure-2

ECG of a 24year old Nigerian showing electrocardiographic features of female ECG pattern; T wave inversion in V1(1), isoelectric ST segment in V2 or V3(1), anticlockwise rotation(1) and heart rate >70beats per minute(1). Total OSDES = 4

Sex differences in ECG pattern had been described in literature irrespective of race. However, the use of ECG in the field of sex determination or verification in young adult population has not been deeply explored. Interpretation of ECG had been based on heart rate, rhythm, intervals, changes in segments, P wave, QRS complex and T wave duration, morphology, axis and amplitudes. Little emphasis was placed on classification of ECG into male and female patterns. Surawicz et al, 2002 described male and female ECG patterns based on the configuration of J point and ST angle¹³. In 2008, Scherptong et al demonstrated significant sex differences in the spatial QRS-T angle¹⁴. The development of OSDES in 2015 at Obafemi Awolowo University, Ile-Ife, Nigeria paved the way for utilization of biological signal such as ECG as part of non-invasive test for assessment of sex in young individuals⁹. In this study, both sensitivity and specificity of OSDES were high. Its sensitivity was higher in males than females while its specificity was

higher in females than males. The result of the validity tests reflected the fact that the scoring system may be very useful clinically for sex determination among the young adults. The usefulness of ECG as a screening test in sports to prevent cardiovascular events cannot be over-emphasized. ECG can be used to diagnosed diseases such as pre-excitation syndromes, heart blocks, arrhythmias, long QTc syndromes and cardiomyopathies especially, hypertrophic cardiomyopathy which can cause sudden cardiac death in athletes¹⁵. In sports, OSDES may be included as one of the initial screening tests for sex verification among young adults to exclude cases of deliberate cheating (men masquerading as women), drug use and abuse, intersex disorders or cardiovascular disorders such as congenital heart diseases, heart blocks and cardiomyopathies. Among the general population of young adults, when a male presents asymptotically with feminine ECG pattern (OSDES <7) or a female presents with masculine ECG pattern (OSDES

≥ 7), the following conditions among other conditions should be excluded; intersex disorders, drug use and abuse especially doping, cardiomyopathies, idioventricular rhythm, bundle branch block, pre-excitation pattern and syndromes, congenital heart diseases and persistent juvenile of T wave changes. In particular, arrhythmogenic right ventricular cardiomyopathy should be considered among the young when male presents with feminine ECG pattern¹⁶. In sports, the electrocardiographic score can be useful as doping test in addition to biochemical test.

Conclusion

This study concluded that the sensitivity and specificity of electrocardiogram in sex verification among young adults were high and that an individual sex can be verified using a biological signal such as electrocardiogram. Moreover, delineation of ECG into masculine and feminine patterns using the electrocardiographic score is advancement with great clinical potentials in the area of ECG interpretation.

Abbreviations: OSDES-Ogunlade Sex Electrocardiographic Score, ECG-Electrocardiogram, TP-True positive, FN-False negative, TN-True negative, FP- False positive, PPV-Positive predictive value, NPV-Negative predictive value, QRS-Ventricular depolarization

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