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ORIGINAL RESEARCH

# A Study of Electrocardiographic Pattern of Normal School Children Aged between 5-15 Years in Nandyal, Andhra Pradesh.

**R. D. Gaikwad[1], M. Lavanya[2], Z. Naveen Kumar[2]**

## ABSTRACT

**Introduction**: Electrocardiography is a simple, non-invasive and relatively cheap investigative tool used for cardiac evaluation. However, there are limited electrocardiographic studies of Indian children. These differences may also be seen in children, hence, the need to develop local reference values.

**Material and Methods**: This was a cross-sectional study on selected 350 subjects. An 12 lead ECG was measured on all subjects.

**Results**: There were one hundred and eighty males (53.3 %) and one hundred and seventy hundred females (46.7 %). The mean heart rate decreased with increasing age. R wave amplitudes were higher in the left precordial leads, in keeping with left ventricular dominance. Mean values were higher in males than females in the three age-groups in most of the precordial and limb leads. In $V_4$R,$V_2$, and-$V_3$highest mean R wave voltages of 0.5±0.1 mV, 1.4±0.3 mV and 1.4±0.2 mV were recorded in the 5-7-year-old. While in $V_5$, and $V_6$the mean R waves were higher in the 12-15-year-old age-group (3.7± 0.5mV and 2.5±0.4 mV respectively). The S-Waves showed progressive decrease in its amplitude on the left precordial leads with increasing age.

**Conclusion:** The mean values in heart rate, QRS duration, PR interval, P wave amplitude showed higher amplitudes in males. Similarly higher amplitudes of R-waves in male children were recorded in precordial leads $V_2$, $V_3$, $V_5$ and $V_6$ in the three age-groups.

**Keywords:** Electrocardiography, children, reference values

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**Conflict of Interest:** None

## INTRODUCTION

Electrocardiography (ECG) is a harmless, painless, noninvasive, easy to perform and relatively inexpensive technique of obtaining information on cardiac activity.[1] In interpreting paediatric ECG, integration of the clinical history, physical examination findings with the ECG report is vital to making a reasonable diagnosis. Interpretation of paediatric ECG is age-dependent and reference standards are required for comparison. The ECG reference standards in Indian adults have been established. The current practice of comparing ECG measurements of Indian children with Caucasian values should be discouraged because it has error level; it is well established that, there are racial differences in the ECG characteristics[2-6] which may also be existent in children. Therefore, there is the need to develop local reference standards.

Although there are pioneer works on ECG on apparently healthy children,[7,8] these studies had limitations which has affected their clinical application. This study seeks to establish reference ranges and any gender differences in the ECG characteristics of children in Nandyal, Kurnool District.

## MATERIAL AND METHODS

The study involved 350 apparently healthy children aged 5-15 years in Nandyal, Kurnool district who were free of any illness at the period of this studycarried out for 6 months i.e June - December 2012.

Those whose blood pressure were more than the 95 percentile for age, sex and height[9]; those with dysmorphic facie; those on any medication known to affect the cardiovascular system[8]; and those with any chronic illness were excluded from the study. Approval to carry out the study was obtained from the Institutional Ethics Committee. Informed consent was obtained from parents or caretakers. The ECG machine was a BPL 108T machine with frequency of 150 Hz and sampling frequency of 1000 Hz. The machine has two speeds, 25 mm/sec and 50 mm/sec; with three levels of sensitivity at 5, 10 and 20 mm/mV. The subjects were classified into age-groups; 5-7, 8-11 and 12-15 year age-groups respectively.

PR interval was measured in lead II, from the beginning of P wave to the beginning of R wave along the horizontal line of the ECG paper. P wave duration was measured in II, from the beginning of the P wave to the end of P wave along the horizontal line of the ECG paper.

QRS complex duration was measured in lead $V_5$, from the beginning of Q wave to the end of the S wave along the horizontal line of the ECG paper. All measurements were done manually by visual inspection using magnifying glass. Second percentile was defined as the lower limit of normal, whilst the 98th percentile was defined as the upper limit of normal.[10]

## STATISTICAL ANALYSIS

Data entry and analysis were carried out using a computer software package; the Statistical Package for Social Sciences version 15. The mean, standard deviation of various ECG variables were determined for both sexes, and 2nd and 98th percentiles of measurement distribution were determined.

## RESULTS

Three hundred and fifty children were studied. There were one hundred and eighty males (53.3 %), and one hundred and seventy females (46.7 %). There were 37.6 %, 43.3 %, and 19.4 % of the 5-7 year age-group, 8-11 year age-group and 12-15 year age-group respectively.

### Heart Rate

The heart rate increased with increasing age and the female groups had higher mean values than the male groups.

### Electrical Axis of The Heart

The electrical axis of the heart in the frontal plane was represented by the QRS-axis. The mean QRS-axis in the three age-groups lay within the normal axis of $0^o$-$90^o$. The axis progressively increased with age and higher mean values were recorded in the male population.

### P Wave Axis

In the three age-groups, the mean P wave axes lay within $0^o$-$90^o$. The lowest mean P wave axis was recorded in the 8-11 year age-group, whilst the highest mean value was in the 5-7 year age-group.

### T Wave Axis

The mean T wave axes for the three age-groups were within $0^o$-$90^o$.The lowest mean T wave axis was $30^o \pm 9^o$, whilst the highest mean value was $50^o \pm 8^o$ in the three age-groups.

### P Wave Amplitude

P wave amplitude was determined using lead II. Higher amplitudes were recorded in 8-11 year age-group and 12-15 year age-groups.

### P Wave Duration

Longer duration was recorded in the older children, in the 12-15 year age-group.

### PR Interval

The PR interval was recorded using lead II. The PR-interval showed variation with age. There was progressive increase in the P-R interval with increasing age and higher mean values were documented in the male population.

QT Interval-Bazett's formula was used to calculate the corrected QT-interval, which was measured from precordial lead $V_5$. The QT and QTc increased with increasing age in the male population, while they were of almost same values in the female population.

### QRS Duration

The mean duration of the QRS complex increased with increasing age. The lowest mean value was $56 \pm 10$ milliseconds, whilst the highest mean of $80 \pm 15$ milliseconds was recorded in the three age-groups. Furthermore, females had relatively lower mean QRS duration when compared to the males all the three age-groups. Table 1: Lead independent ECG indices according to age-groups and gender, showing the mean, standard deviation, 2nd, 98th percentiles and p-values.

### Q Wave

In lead II, the lowest mean Q-wave amplitude was $0.2 \pm 0.1$ mV, whilst the highest mean value of $0.3 \pm 0.1$ mV was recorded in the three age-groups. Highest amplitude was recorded in males of the 8-11 year age-group. In lead III, the lowest mean Q-wave amplitude was $0.10 \pm 0.1$ mV, whilst the highest mean value of $0.26 \pm 0.1$ mV was recorded in the three age-groups. Highest amplitude was recorded in the 12-15 year age-group. In lead aVF, the lowest mean value was $0.1 \pm 0.1$ mV, whilst the highest mean value of $0.2 \pm 0.1$ mV was recorded in the three age-groups. Highest amplitude was recorded in the 8-11 year age-group. In lead $V_5$, the lowest mean value was $0.2 \pm 0.1$ mV, whilst the highest mean of $0.3 \pm 0.1$ mV was recorded in the three age-groups. Highest amplitudes were recorded in the 5-7 and 12-15 year age-groups. In lead $V_6$, the lowest mean Q-wave amplitude was $0.1 \pm 0.1$ mV, whilst the highest mean of $0.3 \pm 0.1$ mV was recorded in the three age-groups. Highest amplitude was recorded in the 5-7 year age-group.

### R-Wave Amplitude

In table 2, tall R waves were predominant in the left precordial leads $V_5$ and $V_6$. The tallest amplitude was recorded in $V_5$, with a mean value of $3.7 \pm 0.5$ mV in the 12-15 year age-group. Lead aVR recorded the lowest amplitude in the 5-7 year age-group with mean value of $0.2 \pm 0.1$ mV. Progressive increase in the magnitude of the R wave from the right sided precordial leads to the left precordial leads was recorded. In the three age-groups, males had higher R wave amplitudes in the left precordial leads than females.Table 2: R wave amplitude in the precordial and limb leads, showing the mean, standard deviation.

**S-Wave Amplitude**

Table 3 depict the S-wave amplitudes of the study population. There were predominant S waves in the right precordial leads in the three age-groups. Highest amplitude was recorded in lead $V_2$ in the three age-groups. There was progressive decrease in the magnitude of the amplitude when traced from $V_1$ on the right to lead $V_6$. In the limb leads, aVR recorded the highest amplitude amongst the three age-groups.Table 3: S-wave amplitude in the precordial and limb leads, showing the mean, standard deviation

**T-Wave Amplitude**

The highest amplitude was recorded in the 12-15 year age-group; whilst the lowest amplitude recorded was in the limb lead aVR. There was a gradual increase in the amplitude in the T wave on the precordial leads with increasing age. Table 4: T-wave amplitude in the precordial leads according to age-groups and gender, showing the mean, standard deviation, 2nd, 98th percentiles values

**DISCUSSION**

ECG parameters recorded were analyzed based on age-groups; 5-7, 8-11 and 12-15 year similar to that used by Davignon et al.[10] The lowest mean heart rates was 75 ± 7 beats per minute, whilst the highest mean was 96 ± 12 beats per

| | | | Age-groups | |
|---|---|---|---|---|
| | | **5-7years** | **8-11years** | **12-15years** |
| Variables | Sex | M±SD (%) | M±SD (%) | M±SD (%) |
| Heart rate(min) | M | 92±10(74-114) | 81±7(66-94) | 77±7(61-89) |
| | F | 96±12(72-120) | 86±5(72-92) | 79±5(68-88) |
| QRS axis(°) | M | 80±5(75-90) | 65±10(45-85) | 60±10(40-80) |
| | F | 75±7(61-90) | 60±10(40-80) | 55±9(37-73) |
| P-wave axis(°) | M | 55±7(41-69) | 50±8(34-66) | 45±10(25-65) |
| | F | 50±7(36-64) | 45±8(29-61) | 45±10(25-65) |
| T-wave axis (°) | M | 50±8(34-66) | 35±10(15-55) | 30±9(12-48) |
| | F | 40±10(20-60) | 35±15(05-65) | 30±10(10-50) |
| P-wave Amplitude (mV) | M | 0.1±0.1(0.1-0.2) | 0.2±0.1(0.1-0.4) | 0.2±0.1(0.1-0.5) |
| | F | 0.2±0.1(0.1-0.4) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.4) |
| P-wave duration(ms) | M | 80±10(60-100) | 80±10(60-100) | 80±10(60-100) |
| | F | 76±10(56-98) | 80±10(60-100) | 80±10(60-100) |
| PR-interval(ms) | M | 120±20(80-160) | 130±20(90-170) | 140±20(100-180) |
| | F | 110±20(70-150) | 120±20(80-160) | 130±15(100-160) |
| QT-interval(ms) | M | 327±22(283-371) | 364±10(344-384) | 376±7(362-390) |
| | F | 316±16(284-348) | 355±10(335-375) | 350±10(330-370) |
| QTc | M | 410±20(370-450) | 420±20(380-460) | 420±24(372-468) |
| | F | 400±15(370-430) | 410±20(370-450) | 400±30(350-460) |
| QRS duration(ms) | M | 59±15(40-90) | 60±15(30-90) | 80±15(60-100) |
| | F | 56±10(40-80) | 58±15(40-88) | 78±10(60-100) |

ms= milliseconds; mV= millivolt; (°) =degree; (%) =2nd-98th %; SD =standard deviation

**Table-1:** Lead independent ECG indices according to age-groups and gender, showing the mean, standard deviation, 2nd, 98th percentiles values.

| | Age-groups | | | | | |
|---|---|---|---|---|---|---|
| | **5-7yrs** | | **8-11yrs** | | **12-15yrs** | |
| | Male | Female | Male | Female | Male | Female |
| Leads | M+SD(°) | M+SD(°) | M+SD(°) | M+SD(°) | M+SD(°) | M+SD(°) |
| $V_4R$ | 0.5±0.1(0.3-0.7 ) | 0.4±0.1(0.3-0.6) | 0.5±0.1(0.3-0.6) | 0.4±0.1(0.3-0.5) | 0.2±0.1(0.1-0.5) | 0.2±0.1(0.1-0.5) |
| $V_1$ | 0.9±0.3(0.3-1.5) | 0.9±0.3(0.2-1.5) | 0.8±0.3(0.3-1.3) | 0.8±0.3(0.2-1.4) | 0.8±0.3(0.2-1.4) | 0.7±0.3(0.2-1.2) |
| $V_2$ | 1.4±0.3(0.8-2.0) | 1.1±0.4(0.3-1.9) | 1.3±0.4(0.6-2.0) | 1.2±0.4(0.4-2.0) | 1.1±0.2(0.7-1.6) | 1.1±0.2(0.2-1.2) |
| $V_3$ | 1.4±0.2(1.0-1.8) | 1.2±0.2(0.8-1.7) | 1.2±0.3(0.6-1.8) | 1.2±0.4(0.5-1.9) | 1.1±0.3(0.5-1.7) | 1.1±0.3(0.7-1.7) |
| $V_5$ | 2.0±0.3(1.4-2.6) | 1.8±0.4(1.1-2.5) | 3.0±0.3(1.4-2.6) | 2.6±0.3(2.0-3.3) | 3.7±0.5(2.7-4.7) | 3.2±0.5(2.3-4.1) |
| $V_6$ | 1.3±0.3(0.8-1.8) | 1.2±0.3(0.6-1.9) | 2.4±0.4(0.8-1.8) | 2.2±0.4(1.4-2.9) | 2.5±0.4(1.7-3.3) | 2.3±0.4(1.6-3.1) |
| I | 0.9±0.3(0.3-1.5) | 0.9±0.3(0.4-1.4) | 1.0±0.4(0.2-1.7) | 0.8±0.3(0.2-1.5) | 1.0±0.4(0.3-1.7) | 1.0±0.4(0.3-1.7) |
| II | 1.2±0.3(0.6-1.9) | 1.0±0.3(0.5-1.6) | 1.3±0.4(0.5-2.1) | 1.1±0.4(0.4-1.8) | 1.4±0.3(0.8-1.9) | 1.3±0.3(0.7-1.9) |
| III | 0.9±0.3(0.4-1.4) | 0.8±0.2(0.4-1.2) | 1.0±0.3(0.4-1.5) | 0.9±0.3(0.4-1.4) | 1.2±0.3(0.7-1.9) | 1.1±0.4(0.4-1.8) |
| aVR | 0.2±0.1(0.2-0.4) | 0.2±0.1(0.1-0.4) | 0.2±0.1(0.2-0.4) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.2-0.5) | 0.2±0.1(0.3-0.5) |
| aVL | 0.6±0.1(0.4-0.9) | 0.6±0.1(0.3-0.9) | 0.7±0.1(0.5-0.9) | 0.6±0.1(0.4-0.8) | 0.6±0.1(0.4-0.8) | 0.6±0.1(0.3-0.8) |
| aVF | 1.0±0.2(0.6-1.4) | 1.0±0.2(0.5-1.3) | 1.0±0.2(0.6-1.4) | 1.0±0.1(0.7-1.2) | 1.2±0.2(0.8-1.7) | 1.1±0.3(0.6-1.7) |

**Table-2:** R wave amplitude in the precordial and limb leads, showing the mean, standard deviation.

| | Age-groups | | | | | |
|---|---|---|---|---|---|---|
| | 5-7yrs | | 8-11yrs | | 12-15yrs | |
| | Male | Female | Male | Female | Male | Female |
| Leads | M+SD(⁰) | M+SD(⁰) | M+SD(⁰) | M+SD(⁰) | M+SD(⁰) | M+SD(⁰) |
| $V_4R$ | 2.0±0.3(1.4-3.0) | 2.0±0.4(1.1-2.7) | 2.1±0.4(1.4-3.0) | 2.0±0.3(1.2-2.5) | 2.2±0.4(1.5-3.0) | 2.1±0.4(1.2-3.0) |
| $V_1$ | 1.8±0.4(1.1-2.5) | 1.7±0.3(1.1-2.4) | 1.9±0.3(1.2-2.5) | 1.8±0.3(0.8-2.3) | 1.9±0.4(1.2-2.6) | 1.8±0.3(1.2-2.5) |
| $V_2$ | 1.7±0.1(0.4-2.0) | 1.6±0.1(1.5-1.7) | 2.0±0.2(1.6-2.2) | 1.8±0.1(1.6-2.0) | 2.0±0.1(1.8-2.2) | 2.0±0.1(1.9-2.1) |
| $V_3$ | 1.3±0.4(0.6-2.0) | 1.0±0.3(0.5-1.5) | 1.7±0.5(0.7-2.7) | 1.4±0.5(0.5-2.3) | 1.6±0.4(0.8-2.4) | 1.3±0.5(0.4-2.2) |
| $V_5$ | 0.4±0.2(0.1-0.7 | 0.3±0.2(0.1-0.6) | 0.3±0.2(0.1-0.7) | 0.3±0.2(0.1-0.7) | 0.3±0.1(0.1-0.5) | 0.3±0.1(0.1-0.5) |
| $V_6$ | 0.4±0.2(0.1-0.7) | 0.3±0.2(0.1-0.6) | 0.3±0.1(0.1-0.6) | 0.3±0.1(0.1-0.5) | 0.3±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) |
| I | 0.3±0.1(0.1-0.4) | 0.2±0.1(0.1-0.4) | 0.3±0.1(0.1-0.5) | 0.3±0.1(0.1-0.4) | 0.3±0.1(0.1-0.4) | 0.2±0.1(0.1-0.3) |
| II | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.4) | 0.3±0.2(0.1-0.7) | 0.3±0.2(0.1-0.6) | 0.3±0.1(0.1-0.5) | 0.2±0.1(0.1-0.3) |
| III | 0.3±0.2(0.1-0.7) | 0.3±0.1(0.1-0.5) | 0.3±0.2(0.1-0.7) | 0.3±0.1(0.1-0.6) | 0.3±0.1(0.1-0.5) | 0.2±0.1(0.1-0.4) |
| aVR | 0.9±0.2(0.5-1.3) | 0.8±0.2(0.4-1.3) | 1.1±0.2(0.7-1.5) | 0.9±0.3(0.4-1.4) | 1.0±0.2(0.6-1.4) | 0.9±0.2(0.4-1.4) |
| aVL | 0.3±0.2(0.1-0.6) | 0.3±0.1(0.1-0.6) | 0.4±0.2(0.1-0.7) | 0.3±0.2(0.1-0.6) | 0.4±0.2(0.1-0.7) | 0.4±0.2(0.1-0.7) |
| aVF | 0.5±0.2(0.1-0.8) | 0.4±0.1(0.1-0.7) | 0.4±0.1(0.2-0.6) | 0.4±0.1(0.2-0.6) | 0.4±0.1(0.2-0.6) | 0.4±0.1(0.2-0.6) |

**Table-3:** S-wave amplitude in the precordial and limb leads, showing the mean, standard deviation

| | Age-groups | | | | | |
|---|---|---|---|---|---|---|
| | 5-7years | | 8-11years | | 12-15years | |
| | M±SD (2-98%) | M±SD (2-98%) | M± SD (2-98%) | M±SD (2-98%) | M± SD (2-98%) | M± SD (2-98%) |
| Leads | Male | Female | Male | Female | Male | Female |
| V4R | 0.2±0.1(0.2-0.4) | 0.2±0.1(0.1-0.3) | 0.3±0.1(0.2-0.4) | 0.3±0.1(0.1-0.4) | 0.4±0.1(0.3-0.5) | 0.3±0.2(0.1-0.6) |
| V1 | 0.3±0.1(0.1-0.4) | 0.3±0.1(0.2-0.4) | 0.3±0.1(0.3-0.4) | 0.3±0.1(0.2-0.4) | 0.5±0.1(0.3-0.7) | 0.4±0.1(0.2-0.6) |
| V2 | 0.4±0.1(0.2-0.5) | 0.3±0.1(0.2-0.4) | 0.4±0.1(0.2-0.5) | 0.3±0.1(0.2-0.5) | 0.7±0.2(0.3-1.0) | 0.7±0.2(0.2-1.0) |
| V3 | 0.3±0.1(0.1-0.4) | 0.3±0.1(0.2-0.4) | 0.4±0.1(0.2-0.5) | 0.4±0.1(0.3-0.4) | 0.8±0.2(0.5-1.1) | 0.7±0.2(0.4-1.0) |
| V5 | 0.5±0.1(0.3-0.6) | 0.4±0.1(0.3-0.5) | 0.5±0.1(0.4-0.6) | 0.4±0.1(0.3-0.5) | 1.0±0.2(0.7-1.3) | 0.9±0.2(0.5-1.3) |
| V6 | 0.4±0.1(0.3-0.6) | 0.4±0.1(0.3-0.6) | 0.4±0.1(0.3-0.5) | 0.4±0.1(0.2-0.5) | 0.9±0.2(0.6-1.2) | 0.9±0.1(0.7-1.1) |
| I | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.3±0.1(0.2-0.4) | 0.2±0.1(0.1-0.3) |
| II | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.4) | 0.2±0.1(0.1-0.4) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) |
| III | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) |
| aVR | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) |
| aVL | 0.2±0.1(0.1-0.4) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.2±0.1(0.1-0.3) | 0.3±0.1(0.2-0.4) | 0.3±0.1(0.2-0.4) |
| aVF | 0.3±0.1(0.2-0.4) | 0.3±0.1(0.2-0.4) | 0.2±0.1(0.1-0.4) | 0.2±0.1(0.1-0.3) | 0.3±0.1(0.2-0.4) | 0.2±0.1(0.1-0.3) |

**Table-4:** T-wave amplitude in the precordial leads according to age-groups and gender, showing the mean, standard deviation, 2nd, 98th percentiles values

minute in the three age-groups. The 5-7 year age-group had higher mean heart rate than the older age-groups. Physiologically the heart rate decreases with increasing age and is attributed to increased autonomic nervous system activity.[11-13] This observation was similar to those reported by Davignon et al[10], Dickson[12] and Rijnbeek et al.[13] Furthermore, females had relatively higher mean heart rates than their male counterparts. These findings were similar to those reported by Edemeka and Ojo,[8] Rijnbeek et al.,[13] Sedat et al.,[14] and Sun et al.[15]

Mean P wave amplitude in lead II remains remarkably unchanged from birth until at least the age of 16 years. After the age of 6-12 months, the 98th percentile value is 0.25 mV. For the diagnosis of right atrial enlargement, P wave amplitude should be greater than the upper limit of normal. The 98th percentile value in this study using lead II was within 0.25 mV, which was in conformity with the reports of Davignon et al,[10] Dickson[12] and Rijnbeek et al.[13]

The P wave duration and PR interval measurements were comparable to Caucasian standards.[15,16] The PR interval increased with increasing age. The lowest PR interval value recorded was in the 5-7 year age-group. This could be due to the fact that the heart rate has influence on the PR interval; the higher the heart rate the shorter the PR-interval.[16]

Typical features of a normal Q wave are that; it has amplitude not more than 0.4 mV and a width of not more than 40 milliseconds. The mean Q waves fulfilled these physiologic characteristics in our study. The presence of Q-wave of more than 0.4 mV alone or in association with tall symmetrical T waves in lead $V_5$ or $V_6$ is often accepted as a sign of left ventricular hypertrophy.[10] The upper limit of Q-wave amplitude recorded in $V_5$ was 0.4mV inmalesof all the age-groups. These were comparable to the findings of Rijnbeek et al[13] but contrasted with that of Davignon et al.,[10] who documented a 98th percentile value of 0.3 mV. This disparity may be attributed to the difference in their sampling rate. While a sampling rate of 1000 Hz was used in this study, Davignonet al.[10] used a sampling rate of 333 Hz. Q wave is a high frequency wave, therefore using a low sampling rate may result in recordings of lower voltages.

The QRS duration hada lowest mean value of 56±10 ms, whilst the highest mean value was 80±15 ms in the three age-groups. This finding was comparable to those of Edemeka et al.,[8] Davignon et al.,[10] and Rijnbeek et al.[13] There was progressive increase in the duration of QRS complex with increasing age which was similar to that of Macfarlene et al [17]

Tall R-waves were observed in this study. Highest amplitude recorded was in the precordial lead $V_5$. These mean values were higher than those of Davignon et al.[10] This trend compared with the report of Rijnbeek et al.[14] who also reported higher R wave amplitudes in the left precordial leads than those of Davignon et al.[10] This difference could be attributed to differences in sampling rate in their studies. Furthermore, higher amplitudes were equally documented in this study when compared to that of Rijnbeek et al.[13] Although taller R-waves have been reported to be common among Indians,[2,3,4,5] differences in modality of ECG reading should be recognized, whilst Rijnbeek et al[13] used 'Modular ECG Analysis System, manual reading was done in this study.

S-waves were predominant on the right precordial lead in the three age-groups. This is because left ventricular dominance is already established by the age of 5-years. S-waves were deeper on the right precordial leads in the 8-11 year age-group when compared to other age-groups. This trend was similar to the findings of Rijnbeek et al.[13] Similarly, higher amplitude S waves were recorded in this study for the three age-groups when compared to that of Rijnbeek et al.[13] This may be due to racial differences between Indian andCaucasian children.

## CONCLUSION

ECG pattern in apparently healthy Nandyalschool children aged 5-15 yearswere determined and the mean values of some of the ECG variables such as the R-waves and S-wave were higher than those reported other studies. However, there was a significant sex difference in the R wave amplitude in the precordial leads $V_2$, $V_3$, $V_5$ and $V_6$ in the three age-groups; the male population having higher amplitudes than the female, which is similar to previous reports.

## REFERENCES


1. Kligfield P, Leonard S, Bailey JJ, Rory C, Barbara JD, William H, Gerard H, Jan AK, Peter M, David MM, Olle P, Pentti R, Galen SW. Recommendation for the standardization and interpretation of the electrocardiogram. Part 1. The electrocardiogram and its technology, a scientific statement from the American Heart Association, electrocardiography and arrhythmia committee, council on clinical cardiology. Circulation 2007; 115:1306-24.
2. Araoye MA. The 12–lead scalar electrocardiogram in negroes. Normal values. Nig Med Pract 1984; 7: 59–65.
3. Araoye MA, George O, Ayodele BOO. Comparison of scalar with vectorial electrocardiogram in axis determination. WAJM 1999; 18(3):187-90.
4. Aroaye MA. Morphological classification of ST-T waveforms in the ECGs of healthy adult Nigerians. WAJM 1983; 117-25.
5. Seriki O, Smith AJ. The electrocardiogram of young Nigerians. Am Heart J 1966; 72: 153–7.
6. Edemeka DBU. The electrocardiogram in healthy Nigerian residents in Lagos state. J pure and Applied Sci 2004; 10: 567-70.
7. Ifere OAS. Heart rate, cardiac rhythm and arrhythmia in normal infants and children. Tropical Cardio 1991; 17: 61-5.
8. Edemeka DBU, Ojo GO. Electrocardiogram in Nigerian children. Saudi Heart J 1996; 7: 44-8.
9. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents.Pediatrics 2004; 114:555-76
10. Davignon A, Rautaharju P, Boiseelle E, Soumis F, Megalas M, Choquette A. Normal ECG standards for infants and children. PediatrCardiol 1979; 1:123-52.
11. Ogbeibu AE. Biostatistics. A practical approach to research and data handling. Benin, Nigeria: Mindex; 2005. p. 25-35.
12. Dickson DF. The normal ECG in childhood and adolescence. Heart 2005; 91:1626-30.
13. Rijnbeek PR, Witsenburg M, Schrama E, Hess J, Kors JA. New limits for the paediatricelectrocardiogram. Eur Heart J 2001; 22:702-11.
14. Sedat K, Ayhan K, Atilla Ý, Hürkan K, Mustafa KL. P wave duration and P dispersion in healthy children.Turk J Pediatr 2003; 45: 133-5.
15. Sun K, Li F, Zhou Y, Dubin AM, Rautaharju PM, Liebman J, Gregg RE, Helfenbein ED, Lindauer JM, Zhou SH. Normal ECG limits for asian infants and children. Cardiology 2005; 455–8.
16. Macfarlene PW, MacLaughlin SC, Devine B, Yang TF. Effects of age, sex, and race on ECG interval measurements. J Electrocardiol1994;27:14-19.