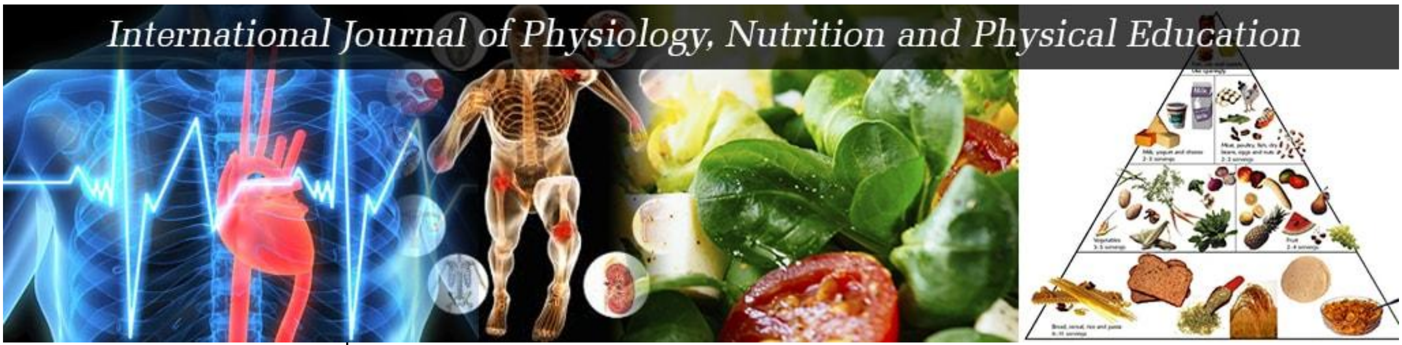

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Interpretation of resting ECG waves in 6-11 years trained male and female tennis players

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Abstract
Objectives: This cross sectional study represents the ECG of 6-11 years male and female trained tennis players. Structural changes that take place in 6-11 years trained tennis players and interpretation of ECG waves on the basis of Seattle Criterion were major objectives of this study. This study also reflects the differences in ECG recordings in both groups.
Design: In this study, 13 male (age 9.08 ±1.66 years) and18 female (age 8.94±1.39 years) trained tennis players were participated. Stature, body weight, and lean body mass were measured by ISAK method.
Methods: Different ECG waves and heart rate were measured by standard 12- leads ECG machine after 30 minutes of rest in lying posture of each player. The room was noise free and the temperature was maintained.
Results: The QRS amplitude in female players (1.76±0.47mv) are significantly ($p<0.05$) higher than male players (1.35±0.39mv). Insignificant differences in age, stature, weight, lean body mass, heart rate, P wave, P-R interval, Q-T interval and QT_C have been observed in two groups.
Conclusion: This cross sectional study reveals that body size in this age group was not significantly differ. Insignificant differences in atrial depolarization, conduction of cardiac impulse from atria to ventricle, ventricular depolarization and repolarization revealed that electrophysiological activities of heart was not differ between two groups. Higher ventricular muscle mass in female trained players could be due to physical training. The interpretations of ECG waves in trained athletes which were mentioned by the Seattle Criterion as training effect, had not been found in 6-11years trained male and female tennis players.

Keywords: ECG interpretation, QTC, Seattle criterion, tennis, 6- 11 years trained players

Introduction
The prevalence of specific ECG findings in athletes may vary according to their age, sex, ethnicity, and level of fitness [1]. Regular sustained physical training can causes the structural and electrical remodeling of heart [2]. These changes are due to the physiological adaptation of heart to regular physical exercise which is considered as athlete's heart. It is obvious that normal ECG of athletes differ from sedentary individual's ECG recording. To prevent cardiovascular hazards, intrinsic cardiac conditions of each athlete should be known properly. Even physical training can be detrimental for athlete without knowing one's initial intrinsic cardiac ability. ECG interpretation in athletes as well as initial training load of a beginner might be meaningful to prevent cardiac failure and proper development of cardiovascular system in athletes. Beside these, interpretation of ECG in athletes can be utilized as a marker in intrinsic cardiac changes for a particular training load.
In Seattle, Washington (26th and 27th February, 2015), an international summit was held with the group of experts in sports cardiology to update contemporary standards for ECG interpretation in athletes through development of an international consensus [3]. The main objectives of this summit meeting were update standard interpretation of ECG and preparing a clear guideline to appropriate evaluation of ECG abnormalities to prevent sudden cardiac death in athletes. In this meeting asymptomatic athletes, age ranges 12-35 years, were considered for the interpretation of ECG. Specific considerations were made for 12-16 years young age group and older athletes' ≥ 30 years because of prevalence of coronary arterial disease sharply increases in these age ranges.

The summary of recommendations for interpretation of ECG in athletes was Sinus Bradycardia (≥30bpm), Sinus Arrhythmia, Ectopic Atrial Rhythm, First Degree AV Block (PR>200ms), Incomplete RBBB, Isolated QRS Voltage Criteria for LVH, Early Repolarization (ST Elevation, J-Point Elevation, J Waves) [4] etc. The summit's reports had suggested that all these changes were due to structural and functional adaptations in heart after exposure to proper training load in athletes. But surprisingly, there were no recommendations for ECG interpretations below 12 years athletes.

Selection of individual for making a successful player starts earlier than 12 years in modern sport arena. Surprisingly, no reports on ECG had been found in 6 -11years trained players, though maximum subjects were selected in this age range for physical training. Even in Seattle Criteria only 12 year onwards ECG interpretation had been mentioned. The current study deals with the interpretation of ECG waves in 6 - 11years trained male and female tennis players. This study is mainly concern with the resting ECG pattern in 6 -11 years trained male and female players for reflecting the electrophysiological changes due to training exposure.

Methods

Thirteen male (age 9.08 ±1.66 years) and 18 female (age 8.94±1.39 years) trained tennis players, age ranges 6-11 years, were participated in this cross sectional study. The selection criterion for players were such that minimum training period they attained not less than one year with the practice session of 5 days per week and duration of around 2-4 hours per day. Prior permission of this project was sanctioned by Institutional Human Ethics Committee. Tennis players were taken from registered Tennis club. No one complained about health problem except a few reporting cold & cough during winter season. Individual National Standard of Living Index and Sports Competition Anxiety Test were performed. All anthropometric measurements and ECG recordings were carried out in temperature and noise controlled departmental laboratories. A written permission was taken from the club authority to conduct the tests with the consents from the guardians of those tennis players. Ambient temperature and humidity were measured by dry bulb, wet bulb and globe thermometer. All measurements were taken between 10 am to 4 pm same day.

Age of the participant was recorded from their birth certificate and it was rounded off to the nearest whole number. Height was measured by ISAK [5] method. Body weight was measured by standard weighing machine with minimum clothing and bare footed. The lean body mass was calculated by ISAK method [5]. Resting Heart Rate (beats/min) was measured after 30 minutes rest in supine posture from ECG recording. P waves (ms), PR interval (ms), QT interval (ms), QT_C (ms) and QRS (mv) of ECG for each player was recorded in the supine posture on a plane surface. BPL Cardiart 6208R automatic 12 leads machine was used in this purpose. QT intervals are usually corrected for heart rate in order to determine whether they were prolonged relative to baseline. Bazett and Friedercia were the most widely used methods of correction. In this study Bazett's Correction (Bazett HC, 1920) [6] was made by - Bazett's Formula=QT interval/square root of RR interval.

Mean values, standard deviations and p values of each mentioned variables of Male and Female players were calculated. Two tail t-tests had done for finding the significance of observed difference between the means of two groups. The level of significance of each variable was considered at 95% ($p<0.05$). Spearman's Rank Correlation coefficients (r) were determined for selected measured variables and its level of significance was considered at 95% ($p<0.05$).

Results

Insignificant differences in age, height, weight and lean body mass of male and female trained tennis players were observed (table 1). The mean of age (years) and height (cm) were higher in male than female tennis player. On the contrary, mean of weight (kg) and lean body mass (kg) were higher in female than male tennis player.

Significant difference ($p<0.05$) was found in QRS (mv) of ECG variables between trained male and female tennis players (table 2). Female had higher QRS (mv) values than male players (Fig. 1). There were no significant differences in heart rate (beats/min), P (ms), PR interval (ms), QT (ms) and QT_C (ms) between male and female tennis player. The mean value of heart rate was higher in female than male player. The mean values of other measured variables like P (ms), PR interval, QT (ms) and QT_C were higher in male than female player (table 2) though these values were statistically insignificant.

Insignificant positive correlations were found among age, height, weight, lean body mass with P, PR interval, QT interval, QT_C and QRS amplitude (table 3) in trained male and female tennis players (table 4).

Table 1: Represents mean, standard deviation (SD), p value & level of significance of age (yrs), height (cm), weight (kg) & lean body mass (kg) in male & female trained tennis players. NS= not significant.

Variables	Male (N=13) Mean±Sd	Female (N=18) Mean±Sd	P Value	Level Of Significance
Age (Yrs)	9.08±1.66	8.94±1.39	0.82	NS
Height (Cm)	135.88±17.99	135.02±11.60	0.82	NS
Weight (Kg)	34.46±8.79	35.53±12.92	0.79	NS
Lean Body Mass (Kg)	29.96±6.26	32.10±10.68	0.50	NS

Table 2: Represents mean, standard deviation (SD), p value & level of significance of heart rate (beats/minute), P (ms), PR (ms), QT (ms), QTC (ms) & QRS (mv) in male & female trained tennis players. NS= not significant.

Variables	Male (N=13) Mean±Sd	Female (N=18) Mean±Sd	P Value	Level Of Significance
Heart Rate (beats/min)	89.08±14.23	92.89±12.34	0.44	NS
P(ms)	93.28±10.16	92.56±6.54	0.80	NS
PR(ms)	124±12.08	120.11±11.61	0.38	NS
QT(ms)	347.08±27.6	340.89±18.24	0.49	NS
QTc(ms)	428.23±17.63	419.72±20.82	0.23	NS
QRS(mv)	1.35±0.39	1.76±0.47	0.01	$P<0.05$

Table 3: Represents Correlation Values Of Height (cm), Weight (kg) & Lean Body Mass (kg) with P (ms), P-R (ms),Q-T (ms), QTc (ms), QRS (mv) in trained female (n=18) tennis players.

Variables	P(ms)	PR(ms)	QT(ms)	QTc(ms)	QRS(mv)
Height(Cm)	R value= +0.143 P value=.572 Not significant	R value= +0.373 P value=.128 Not significant	R value= +0.011 P value=.964 Not significant	R value= +0.123 P value=.627 Not significant	R value= +0.031 P value=.903 Not significant
Weight(Kg)	R value= +0.024 P value=.925 Not significant	R value= +0.216 P value=.388 Not significant	R value= +0.129 P value=.610 Not significant	R value= +0.060 P value=.813 Not significant	R value= +0.083 P value=.744 Not significant
Lean Body Mass(Kg)	R value= +0.318 P value=.241 Not significant	R value= +0.189 P value=.468 Not significant	R value= +0.107 P value=.683 Not significant	R value= +0.150 P value=.567 Not significant	R value= +0.222 P value=.392 Not significant

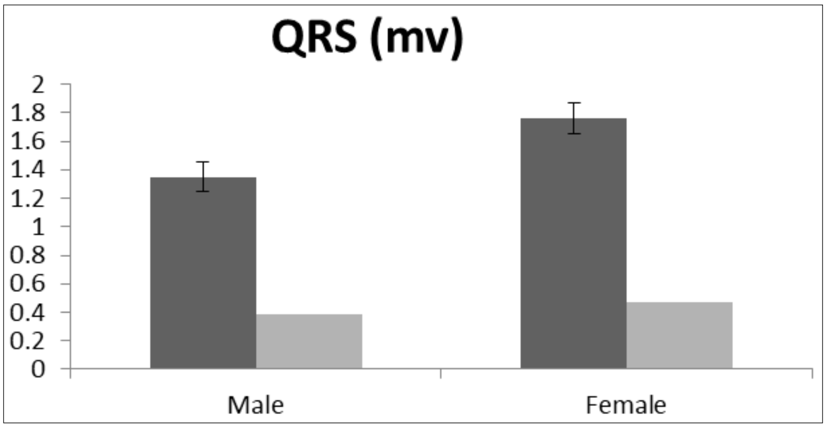

Fig 1: Mean±SD Values of QRS (mv) Of Male and Female

Discussion

The duration, amplitude and morphology of QRS complex have important role in reflecting different cardiac abnormalities like cardiac arrhythmia, conduction abnormalities, ventricular hypertrophy, myocardial infarction, electrolyte derangements and other cardiac diseases [7]. In 12 to 35 years trained person, some of the above mentioned cardiac abnormalities were considered as biological adaptations of heart after Seattle Criteria [4]. But no reporting of ECG below 12 years children had been found whereas maximum individuals were selected even in early stage for training. This study reflects trained female players have higher QRS amplitude than male players and it might be due to their more ventricular mass. No reliable reference value for any ECG variables below 12 years trained players had been found till date, so these findings cannot claim whether these ECG values were within normal range or any training effects reflected in male or female trained players. Only assumptions can be made on the basis of available reference values settled after Seattle Criteria for trained athletes.

Trained endurance athletes are unique group of individuals with increased ventricular mass and resting heart rates generally less than 60 beats/min. Electrocardiographic normal standards, especially those for QTc interval do not exist for these trained individuals [8]. Trained players are always morphmetrically different from untrained individuals and Seattle Criteria specify the ECG changes in 12-35 years trained athletes.

This study indicates neither male nor female junior (6-11years) trained players have heart rate below 60 beats/minute (Table-1). So it can be claimed according to Seattle criteria that load of physical training is not sufficient to produce Bradycardia in both male and female trained players. Only two male and two female trained players show sinus arrhythmia out of total 31 players.

This study reveals that there are insignificant differences in atrial depolarization (P wave) between trained male and female junior players which might be due to their similar morphometric changes in heart. But it cannot be claimed because echocardiography had not been done in this cross sectional study. The P-R interval reflects conduction time of the impulse from SA node to the ventricles. The mean duration of P-R interval is relatively shorter in female than male [9]. The reference value of P-R interval is 120-200 ms and our findings for both male and female junior trained players exist within normal range. According to Seattle Criteria P-R interval ≥ 200 ms can be considered as normal in 12-35 years trained athletes due to cardiac adaptation after exposure to physical training. So, based on Seattle interpretation no improvement in conduction velocity was observed in trained male and female junior tennis players. Therefore, we assumed that physical training among the junior tennis player might not be sufficient to influence the conduction velocity of cardiac impulse from SA node to AV node. The Q-T interval is the total ventricular systolic time measured from the onset of Q wave to the end of the T wave. A prolonged QT time is one of the most important electrocardiographic abnormalities and a cause of sudden cardiac death [10]. Trained endurance players have generally high left ventricular muscle mass and higher QTc values than untrained individuals. QTc is a popular marker of ventricular repolarization [11]. In this study, both QT and QTc mean values were found lower in female than male players though it varies insignificantly.

Insignificant correlations (Table 3&4) among selected variables of physical and electrophysiological activities of heart suggest that studied ECG waves did not influenced by body size and composition in this age ranges (6-11).

Conclusion
The current study deals with 6 -11years trained male and female tennis players. Aerobic endurance training influences functional and morphological changes in heart that can be reflected in the 12- lead ECG. The most common findings in trained players are rhythm disorders and changes in the repolarization pattern.

In this cross sectional study, 13 male and 18 female trained tennis players, clinically “healthy”, ages 6 to 11 years, shows insignificant differences in electrocardiographic characteristics except QRS amplitude (mv). The QRS amplitude is significantly higher in trained junior female players than male players. So, it can be concluded that ventricular mass is higher in trained female junior tennis players than male players though echocardiography is needed to specify the ventricular hypertrophy. This study also represents the ECG pattern of trained male and female players belong to 6 - 11 years. Until and unless we have any reference values in ECG waves of trained male and female players in this age ranges, proper interpretation could not be possible. If we consider Seattle Criterion even in this age range (6-11), then it can be concluded that no such development had been observed in structural and electrophysiological aspects of heart both in male and female trained players after regular physical training. The effectiveness of training in terms of cardiac development can be evaluated by the proper interpretation of ECG during training session using Seattle Criteria.

Using Seattle Criteria for the assessment of cardiac development after physical training and interpretation of ECG in trained players (6 -11years) are new approach. It needs more research to justify the importance of ECG interpretation in trained junior athletes. This study only provides the basic information about electrophysiological status of junior trained players after Seattle Criteria.

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