Research Article

A comparative study on the cardiac functioning of endurance athletes, speed athletes, and untrained individuals

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Abstract

Background: The cardiac morphology and functioning undergoes a variety of changes on physical training, and it depends on the type of training the person undergoes. Endurance training and speed training are the two major classifications in it, and it is essential to know which type overruns the other in increasing the cardiac functioning. **Aims and Objective:** To compare the cardiac functioning of three groups of human participants' viz., endurance athletes, speed athletes, and untrained individuals, by measuring their VO_2 max and QRS wave amplitude. **Materials and Methods:** Fifteen endurance athletes (mean age ± SD: 20.27 ± 1.58 years), 15 speed athletes (mean age ± SD: 20.15 ± 1.85 years), and 15 control subjects (mean age ± SD: 19.33 ± 0.82 years) were recruited into the study. VO_2 max was obtained from three tests (beep test, Uth–Sorensen–Overgaard–Pedersen method, and Cooper variation method), and mean QRS wave amplitude was measured using Minnesota code of classification. Statistical analysis was done using ANOVA test. **Result:** The VO_2 max (V) and QRS wave amplitude (R) of endurance (V: $P < 0.001$; R: $P < 0.001$) and speed athletes (V: beep test—$P < 0.05$, others—$P < 0.001$; R: $P < 0.05$) were significantly higher than that of the untrained individuals. When compared between the two athletic groups, endurance athletes showed significantly higher values than the speed athletes in both the parameters (V: $P < 0.001$; R: $P < 0.001$). **Conclusion:** Both endurance and speed training enhance the cardiac functioning when compared with the untrained individuals significantly. But, endurance training shows an edge over speed training in increasing the effectiveness of working of heart.

KEY WORDS: Cardiac Functioning; Endurance Athletes; Speed Athletes; QRS Wave Amplitude; VO_2 max

Introduction

The cardiac morphology and functioning undergoes a variety of changes on physical training. But, the change varies from the type of training a person undergoes. Endurance training helps an individual work for a longer period of time without undergoing fatigue but with less intensity; whereas, a person undergoing speed or strength training helps him work with more intensity but for a short period of time. Both types of training enhance cardiac functioning, but it is important to know the level of enhancement in both the types. Athletes show a better cardiac functioning attributed to their enhanced vagal tone, which in turn causes a resting bradycardia.[1]

VO_2 max is the rate of oxygen usage under maximal aerobic metabolism, which is measured in mL/kg/min.[2] It reflects on various cardiac parameters such as muscle size, stroke volume, cardiac output, and resting heart rate.[3] Changes in the VO_2

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max correspond to the differences in the ventricular diastolic performance,[4] and these values show a high correlation with the cardiac functioning of human body.[5] Hence, this measurement is an indirect measurement of the cardiac function.

Electrocardiogram is a measurement of the electrical activity of the heart. It is measured using the standard 12-lead ECG. QRS wave amplitude in it is a measure of the ventricular contractility, as it occurs during the phase of ventricular depolarization.

Studies have compared the cardiac functioning of endurance athletes with speed athletes mentioning that endurance athletes show a better cardiac functioning shown by their systolic and diastolic function[6–8] but not by relating the two variables VO_2 max and QRS wave amplitude in a 12-lead ECG. Thicker left ventricular walls and more marked systolic blood pressure response to strength exercise in endurance athletes were directly intercorrelated, which indicates an increased pumping capacity in the cardiac muscles of endurance athletes.[7] However, speed athletes showed an increased left ventricular mass when compared with the endurance athletes in another study.[9]

Hence, we conducted a cross-sectional comparative study to compare the above-mentioned two variables, as a measure of the cardiac function, of athletes and the normal individuals and to compare the two athletic groups namely, endurance athletes and speed athletes.

MATERIALS AND METHODS

Participants

Forty-five male participants in the age group of 18–25 years were involved in the study. Fifteen untrained individuals (mean age ± SD: 19.33 ± 0.82 years) who had not taken any formal athletic training formed the control group. Fifteen endurance athletes (mean age ± SD: 20.27 ± 1.58 years) and 15 speed athletes (mean age ± SD: 20.15 ± 1.85 years) formed the endurance and speed athletic groups, respectively. All the athletes were involved in at least 2 years of training, which involved 7–10 h of training per week in their specific discipline, and are part of Coimbatore District Athletic Association. The study was explained to the coaches, officials, and athletes, and voluntarily willing participants were recruited in the study. Fifteen athletes for each group, who fulfilled the qualifying criteria for that particular group, were then picked up randomly from the voluntarily willing participants. The untrained individuals were also chosen in a similar fashion from our institution. All those who showed history of heart disease or are known cases of cardiac disease are excluded from the study. The study was approved by the Institutional Human Ethics Committee, and it complied with the Declaration of Helsinki regarding human experimentation. All the participants were told about the procedures, benefits, and risks associated with participation in the study, and a written informed consent was obtained.

Procedure

It was a cross-sectional comparative study. The participants were grouped into three groups namely, endurance athletes, speed athletes, and untrained individuals based on their training and their competitive performance. The study involved assessing VO_2 max and QRS wave amplitude of the participants.

VO_2 max assessment. VO_2 max in mL/kg/min was measured in the participants by three tests namely, (i) multistage fitness test (beep test), (ii) Uth–Sorensen–Overgaard–Pedersen method, and (iii) Cooper variation method. After a standardized warm-up lasting for 20 min, followed by 2 min of rest,[10] each participant performed the three tests on three consecutive weeks leaving exactly 7 days gap in between each test to ensure adequate recovery and not to disturb their routine training. The tests were performed on outdoor synthetic field. They were conducted during the same hours of the day between 4 p.m. and 6 p.m. (±30 min) to minimize the circadian rhythm. Their training was kept to the least intensity 48 h prior to ensure full performance. The participants were refrained drinks containing caffeine 12 h prior to the tests and consumed their last light meal at least 3 h before each test.

(i) The multistage fitness test or beep test[11] is a running test that involves running continuously between two points that are 20 m apart synchronized with a soundtrack, which beeps at set intervals. As the test proceeds, the frequency of the sound signal increases in such a way that the speed is increased by 0.5 km/h each min from a starting speed of 8.5 km/h. The test stops when the subject is no longer able to match the set pace[12]. There are 21 levels with each level comprising of definite number of shuttles. The subject's shuttles and levels were obtained (e.g., 8–11 indicates at 11th shuttle of 8th level, he stopped), and VO_2 max is calculated from it using the following formula.[13] [equations 1–4]:

Ends = level $\times$ 0.4325 + 7.0048 (1)
Deci = shuttles/ends (2)
Score = 1 $\times$ level + Deci (3)
VO_2 max = 3.46 $\times$ score + 12.2 (4)

(ii) Uth–Sorensen–Overgaard–Pedersen method[14] involves measuring the maximum and resting heart rate and calculating the VO_2 max from it. Maximum heart rate is obtained from this equation.[15] [equation 5]:
Maximum heart rate = 208 $\times$ (0.7-age of the individual) (5)

Resting heart rate is the heart rate measured after 10 min of rest[16]

VO_2 max is then assessed from the following equation [equation 6]:

VO_2 max = 15.3 $\times$ maximum heart rate/resting heart rate (6)

(iii) Cooper variation method is another running test where the subjects are asked to run for 12 min at their maximal effort, and VO_2 max is calculated from the distance they have run in the time limit of 12 min using the given equation.[17] [equation 7]:

VO_2 max = (d_{12}-505)/45, (7)

where d_{12} is the distance covered in 12 min of running with full effort.

Electrocardiogram. The 12 lead ECG was taken in athletes on the fourth week during the same time of the day, and QRS

Table 1: VO_2 max and QRS wave amplitudes of three groups of study participants

Dependent variable	Study groups	Mean ± SD	*F*	*P*
VO2 max (mL/kg/min)				
Beep test	Untrained individuals	32.94 ± 5.06	65.79	<0.001
	Endurance athletes	51.38 ± 4.30		
	Speed athletes	36.64 ± 4.59		
Uth–Sorensen–Overgaard–Pedersen method	Untrained individuals	41.15 ± 2.05	143.78	<0.001
	Endurance athletes	59.48 ± 3.89		
	Speed athletes	47.25 ± 2.82		
Cooper variation method	Untrained individuals	31.64 ± 4.88	141.06	<0.001
	Endurance athletes	64.52 ± 4.86		
	Speed athletes	45.90 ± 6.27		
QRS wave amplitude (mV)				
ECG analysis using Minnesota code of classification	Untrained individuals	1.467 ± 0.47	31.10	<0.001
	Endurance athletes	2.740 ± 0.48		
	Speed athletes	1.810 ± 0.42		

wave amplitude was measured in them using Minnesota code of ECG classification.

Minnesota code of classification for High Amplitude R Waves[18]

3-1 Left: R amplitude > 26 mm in either V5 or V6, or R amplitude > 20.0 mm in any of leads I, II, III, aVF, or R amplitude > 12.0 mm in lead aVL (all criteria measured only on second to last complete normal beat).

3-2 Right: R amplitude ⩾ 5.0 mm and R amplitude ⩾ S amplitude in the majority of beats in lead V1, when S amplitude is > R amplitude somewhere to the left on the chest of V1 (codes 7-3 and 3-2, if criteria for both are present).

3-3 Left (optional code when 3-1 is not present): R amplitude > 15.0 mm but ⩽ 20.0 mm in lead I, or R amplitude in V5 or V6, plus S amplitude in V1 > 35.0 mm (measured only on second to last complete normal beat).

3-4 Criteria for 3-1 and 3-2 both present.

Statistical Analysis

Data were analyzed using SPSS software, version 19. Mean and standard deviations were calculated for continuous variables. ANOVA was done to compare the mean values and statistical significance between different groups. Post hoc comparisons were done further using least significance difference method. $P < 0.05$ was considered as statistically significant.

RESULT

VO_2 max Analysis

Comparison between endurance athletes and untrained individuals. The VO_2 max of endurance athletes in all three tests [beep test (51.38 ± 4.30 against 32.94 ± 5.06), Uth–Sorensen–Overgaard–Pedersen method (59.48 ± 3.89 against 41.15 ± 2.05), and Cooper variation method (64.52 ± 4.86 against 31.64 ± 4.88)] showed significant increase ($P < 0.001$) when compared with the untrained individuals.

Comparison between speed athletes and untrained individuals. The VO_2 max of speed athletes showed a significant increase with $P < 0.05$ in beep test (36.64 ± 4.59 against 32.94 ± 5.06) and $P < 0.001$ in Uth–Sorensen–Overgaard–Pedersen method (47.25 ± 2.82 against 41.15 2.05) and Cooper variation method (45.90 ± 6.27 against 31.64 ± 4.88).

Comparison between endurance athletes and speed athletes. The VO_2 max of endurance athletes in all three tests [beep test (51.38 ± 4.30 against 36.64 ± 4.59), Uth–Sorensen–Overgaard–Pedersen method (59.48 ± 3.89 against 47.25 ± 2.82), and Cooper variation method (64.52 ± 4.86 against 45.90 ± 6.27)] showed a significant increase with $P < 0.001$ when compared with the speed athletes [Figure 1].

ECG Analysis

Comparison between endurance athletes and untrained individuals. There was a significant increase in the QRS wave amplitude of endurance athletes (2.74 ± 0.48 mV) when compared with the control group (1.467 ± 0.47 mV) with $P < 0.001$.

Comparison between speed athletes and untrained individuals. There was a significant increase in the QRS wave amplitude of speed athletes (1.810 ± 0.42 mV) when compared with the control group (1.467 ± 0.47 mV) with $P < 0.05$.

Comparison between endurance athletes and speed athletes. There was a significant increase in the QRS wave amplitude of endurance athletes (2.74 ± 0.48 mV) when compared with the speed athletes (1.810 ± 0.42 mV) with $P < 0.001$ [Figure 2].

DISCUSSION

By inferring the results, it is well understood that both the endurance and speed athletes showed a higher VO_2 max (beep

Table 2: Post hoc analysis and significant differences among three groups of study participants

Dependent variable	Group of significance	Comparison group	*P*
VO_2 max (mL/kg/min)			
Beep test	Endurance athletes	Untrained individuals	<0.001
		Speed athletes	<0.001
	Speed athletes	Untrained individuals	<0.05
Uth–Sorensen–Overgaard–Pedersen method	Endurance athletes	Untrained individuals	<0.001
		Speed athletes	<0.001
	Speed athletes	Untrained individuals	<0.001
Cooper variation method	Endurance athletes	Untrained individuals	<0.001
		Speed athletes	<0.001
	Speed athletes	Untrained individuals	<0.001
QRS wave amplitude (mV)			
ECG	Endurance athletes	Untrained individuals	<0.001
		Speed athletes	<0.001
	Speed athletes	Untrained individuals	<0.05

test, Uth–Sorensen–Overgaard–Pedersen method, and Cooper variation method) and QRS wave amplitude of ECG when compared with the untrained individuals.

Because the above-mentioned two variables are used as the parameters for measuring cardiac functioning, the athletic group showed a better cardiac functioning as signified by the result. It implies that any sort of physical training will enhance the cardiac functioning if done continuously for months together. This supports the evidence formed by studies mentioning that the athletes show a decreased resting heart rate owing to increased vagal tone.[19] Athletes' heart is predominantly associated with a programed, intensive training. But, as there are different kinds of physical activities, the degree of these changes is highly variable.[20] For this aspect, it is essential to know which type of physical activity will increase the cardiac functioning of an individual.

After comparison of the two comparison groups, considering the dependent variable, VO_2 max, all the three tests namely, the beep test, Uth–Sorensen–Overgaard–Pedersen method, and the Cooper variation method showed a much higher mean value for endurance athletes when compared with speed athletes with an extreme statistical significance ($P < 0.001$) indicating that endurance athletes have a very high oxygen carrying capacity when compared with the speed athletes. Structurally,

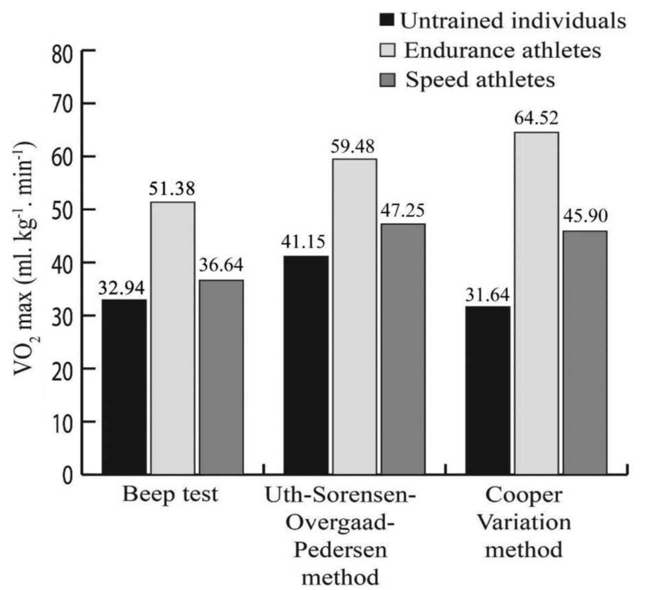

Figure 1: Mean VO_2 max values of three groups of study participants.

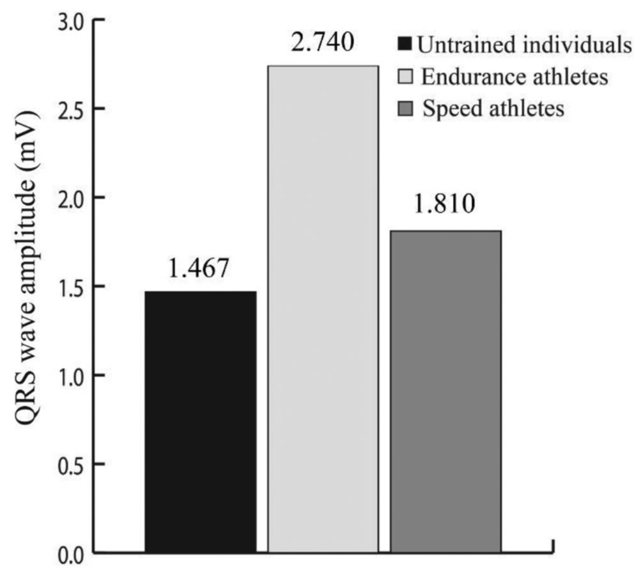

Figure 2: Mean QRS wave amplitude values of three groups of study participants.

endurance athletes develop left ventricular dilatation with enhanced diastolic function and biatrial enlargement, whereas speed athletes develop left ventricular hypertrophy and diminished diastolic function.[6] Even in endurance athletes, during the initial few months, the left ventricles (LVs) develop only concentric remodeling with increased mass to volume ratio, but only after 6–9 months, they develop the characteristic eccentric remodeling with ventricular dilatation apart from the hypertrophy.[21] In another study, left ventricular wall thickness was assessed and correlated with systolic blood pressure, which revealed increased LV thickness and systolic BP in endurance athletes indicating an increased pumping capacity and a better cardiac functioning in the endurance athletes.[7] The increase in amplitude of QRS wave ($P < 0.001$) also indicates that endurance athletes show a better cardiac functioning. The increase in amplitude of QRS wave contributes to the increased pumping capacity and stroke volume in endurance athletes. It also provides substance for prescribing endurance exercise for enhancing cardiac functioning of an individual, although the constraints and degree of workload has to be determined in further studies. Patients with hypertrophic cardiomyopathy also provide a similar picture as athletes' hypertrophied heart but, athletes have larger LV cavity, aortic root, and left atrial size.[22] The enhanced cardiac functioning in endurance athletes could form a substantial evidence for promoting endurance training in treating and preventing cardiac diseases, as supported by a study, which states that exercise training improves exercise capacity and left ventricular diastolic function.[23] However, further research is required to study the two athletic groups using many more functional parameters to establish a working relationship with the type of training and the functioning of heart.

Conclusion

Hence, two inferences could be made from the test: (i) both endurance and speed training enhances the cardiac functioning when compared with the baseline untrained individuals significantly and (ii) endurance training shows an edge over speed training in increasing the effectiveness of working of heart.

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