Cardiovascular modifications in long-distance athletes from Villa Clara during the 2018-2019 macro-training cycle

Abstract

A descriptive longitudinal section study was carried out with the objective of describing the electrocardiographic and echocardiographic cardiovascular modifications in different stages of the preparation of a macro-training cycle, in the seven long distance runners of the Villa Clara school category. It is concluded that training produces cardiac morphological and functional adaptations that are manifested through electrocardiographic findings such as bradycardia and sinus arrhythmia; in addition to modifications of echocardiographic variables such as the thickness of the interventricular septum and the posterior wall of the left ventricle that show values close to the upper limit of normality and diastolic diameter of the left ventricle with low mean values during all training stages, which contributes at a high h / r ratio in most athletes. The ejection volume and the ejection volume index maintain values lower than those considered normal during the training stages, which leads to the suggestion that there is an increase in work intensities throughout the macrocycle and a marked deficit of aerobic capacity. This suggests not having made adjustments to training loads and neglecting basic aerobic work during the preparatory period.

Keywords: *cardiovascular modifications, macrocycle, training, background*

Introduction

Since the XIX century, it has been proposed that both prolonged and intense physical exercise and systematic sports training can produce acute changes (responses) and chronic changes (adaptations) of the cardiovascular system, directly related to the type, duration and intensity of training and to the years of sports practice (Semsarian, 2015).

Its clinical expression depends on genetic, metabolic, humoral factors and to a great extent on the type of training; which has been a source of interest for coaches, physiologists and doctors, both in the search to know its impact on health, as well as on the performance of athletes (Thompson, 2016).

Myocardial electrical and structural changes with a moderately increased mass and high work capacity caused by repeated cardiac overload induced by regular exercise and which does not present any valvular abnormality or other serious disorder in addition to being determined by various factors, come to configure an entity of its own: the heart of the athlete, according to several authors, including (Velarde, 2016).

The training typical of sports with a predominance of dynamic and resistance exercise induces morphological and functional cardiovascular adaptations: decrease in heart rate, increase in the volume of the cavities, the thickness of the wall thicknesses, increase in the stroke volume and the capacity to dilation of the heart (Yáñez, 2016).

In Cuba there are investigations in various sports in which the structural and functional findings of the heart are related to the stages of sports preparation, where the different functional directions of the loads are taken into account and knowledge of the modifications of the electrocardiographic variables is achieved. and echocardiography that express the cardiovascular adaptations that occur during the progression of training in the different stages of the preparatory period in the sports studied (Rabassa, 2009). (Silva, Portela, Pujadas and Medina, 2017). (Berovides, 2016).

In the province of Villa Clara, with the intention of supporting the control of sports training, studies have been carried out in several sports in recent years, where other echocardiographic variables that appear less frequently in the reviewed literature but with high and novel criteria are also exposed. Among these diagnoses are: left ventricular concentric hypertrophy indices, asymmetric septal hypertrophy, h / r index, ejection volume index, cardiac output index and myocardial mass index (Rabassa, 2009). (Rabassa, 2011).

All of the above, together with the background of the scarce cardiovascular profile investigations in long-distance athletics in the early initiation stage, named in Cuba as a school category, are elements that have been taken into account to study the characteristics of the heart in long-distance runners. of these ages in the province of Villa Clara, using highly reliable measurements to know the state of the cardiovascular system of athletes so young in this sport and provide information for teachers, doctors and athletes in order to achieve adequate control biomedical training, disease prevention, quality of life improvements and sports performance.

The objective of the work is to describe the electrocardiographic and echocardiographic cardiovascular modifications in different stages of the preparation of a macro-training cycle, in the long-distance athletes of the Villa Clara school category.

Methodology

A descriptive study of longitudinal section was carried out on the entire population of athletes, of both sexes, from the school category endurance team of the “Héctor Ruiz” Sports Initiation School (SIS) in Villa Clara. Of the seven athletes, four are male and three female, with an average chronological age of 12.7 years and a sporting age of 3.1 years respectively.

An exhaustive cardiovascular physical examination, weight and height were carried out to calculate the body surface; as well as the electrocardiogram and echocardiogram at rest in the three moments of sports preparation: beginning and end of general preparation (GPS, GPE) and end of special preparation (SPE) always in the morning, without having trained that day nor having received heavy training loads the day before.

The general variables studied were chronological age and sports age; Electrocardiographic: the electrocardiograms were reviewed according to the established methodology for their interpretation and the findings found were described as variables and finally the echocardiographic variables, those considered fundamental for the echocardiographic control of the influence of physical loads were used with the premise of the existence of normal systolic and diastolic functions: interventricular septum in diastole (ISd), posterior wall of the left ventricle in diastole(LVPWd), diastolic diameter of the left ventricle (DDLV), ejection volume or stroke volume (EV), h / r index (I h / r), stroke volume or stroke volume index (SVI).

Operational definition of the last echocardiographic variables studied and that are not commonly described when echocardiograms are performed:

1. h / r index: It is calculated through the formula:

$$h / r \text{ index} = \frac{IS_d + LVPW_d}{DDLV}$$

Where "h" is equal to the sum of the thickness of the interventricular septum and the posterior wall of the left ventricle, both measured in diastole; the "r" is the diastolic diameter of the left ventricle.

Measurement indicators: The values accepted as normal or balanced in young adult athletes and that are an expression of a metabolically balanced work (aerobic-anaerobic) is between 0.32 and 0.40 (ideal between 0.34 and 0.36) (Rabassa, 2009). (Berovides, 2016).

2. Volume of ejection index (VEI)

$$VEI = VE / SC$$

Where VE: stroke volume or stroke volume.

VEI: ≥ 50 ml / beat / m2, it is considered an indicator of good aerobic capacity.

For the statistical processing of the information, the spreadsheet in Microsoft Excel 2010 was used, which allowed to summarize and process the collected data and reflect them in tables for their adequate interpretation.

Results and Discussion

Table 1. Heart Rate in the training stages.

Heart rate	Training Stages					
	GPS		**GPE**		**SPE**	
	$N_{ro.}$	%	$N_{ro.}$	%	$N_{ro.}$	%
Sinus Rhythm	3	42,8	2	28,6	3	42,8
Sinus arrhythmia	2	28,6	2	28,6	2	28,6
Sinus bradycardia	1	14,3	2	28,6	1	14,3
Sinus tachyarrhythmia	1	14,3	1	14,3	1	14,3

Source: Clinical history.BGP: beginning of general preparation,,EGP: end of general preparation,,ESP: end of special preparation

42.8% of the athletes had a sinus rhythm that is normal, 57.2% presented modifications in the heart rhythm because 4 of 7 athletes maintained some type of change in any of the 3 stages of training, the respiratory-type sinus arrhythmia, sinus bradycardia and sinus tachyarrhythmia were found.

Table 2. Values of the electrocardiographic variables: Heart rate and PR interval.

Variables	**Heart rate(I/mto)**			**IntervalPR(seg)**		
	Stages			**Stages**		
Athletes	GPS	GPE	SPE	GPS	GPE	SPE
1	62	61	65	0,22	0,24	0,23
2	67	67	68	0,16	0,12	0,16
3	60	58	60	0,12	0,16	0,12
4	76	74	71	0,16	0,16	0,16
5	57	57	59	0,16	0,16	0,16
6	79	68	68	0,16	0,12	0,12
7	117	110	123	0,16	0,12	0,20
DS	20.5	15.9	22.3	0.029	0,042	0,039
Average	74.0	70.1	73.4	0.16	0.16	0.16
Average Macrocycle	72,5			0,16		

Source: Clinical history. l / mto: beats per minute, sec: seconds.

In Table 2, when analyzing the heart rate, it is observed that 4 athletes (57.2%) of the population presented values that ranged between 61 and 79 l / m in all stages and 2 cases (28.6%) showed heart rate between 57 and 60 l / mt, expected values in athletes with a mean sporting age of 3.1 years (between low normal and sinus bradycardia). Finally, one athlete (14.3%) in the three stages showed heart rate values above 100 l / mt. In the case of the PR interval, the mean value of this variable in the studied population agrees in the three moments with values considered normal, except for one athlete who represented 14.3% presented lengthening in its duration corresponding to atrioventricular block first grade.

Table 3. Values of the electrocardiographic variables: QRS complex and QTc interval.

Variables	ComplexQRS(seg) Stages			IntervalQTc (mseg) Stages		
Athletes	GPS	GPE	SPE	GPS	GPE	SPE
1	0,07	0,07	0,07	412	305	357
2	0,08	0,06	0,08	409	424	439
3	0,08	0,08	0,08	422	440	423
4	0,08	0,07	0,08	395	380	361
5	0,08	0,08	0,08	380	378	378
6	0,07	0,06	0,06	351	357	440
7	0,06	0,06	0,06	337	343	364
DS	0,004	0,004	0,009	32,2	48,3	36,7
Average	0,06	0,08	0,06	386	375	334
Average Macrocycle	0,06			365		

Source: Clinical history. msec: milliseconds, GPS: general preparation start,GPE: general preparation end,SPE: special preparation end.

In Table 3, it can be seen that the seven athletes studied maintained values within the normal range for the QRS Complex and QTc variables during the three stages analyzed with means during the macrocycle of 0.06 sec and 365 msec, respectively.

Table 4. Ventricular repolarization in the training stages.

Ventricular Repolarization	**Training Stages**		
	GPS	**GPE**	**SPE**

	$N_{ro.}$	%	$N_{ro.}$	%	$N_{ro.}$	%
Normal Ventricular Repolarization	3	42,8	3	42,8	3	42,8
Flattened T wave	2	28,6	2	28,6	2	28,6
Inverted and deep T wave	2	28,6	2	28,6	2	28,6

Source: Clinical history.

Table 4 describes the presence or absence of ventricular repolarization disorders, it was observed that 4 of the 7 athletes presented ventricular repolarization disorders in the three stages evaluated, which represented 57.1% of the total sample in study; the inverted T wave and the flattened T wave were the alterations found considered minor disorders of ventricular repolarization.

Table 5. Values of the echocardiographic variables: interventricular septum, posterior wall, diastolic diameter and h / r index.

Variables	**IVSd(mm)**			**PWLVd(mm)**			**DDLV (mm)**			**Índex h/r**		
Athletes	**Stages**			**Stages**			**Stages**			**Stages**		
	GPS	GPE	SPE	GPS	GPE	SPE	GPS	GPE	SPE	GPS	GPE	SPE
1	8	11	11	8	9	8	39	36	39	0,41	0,52	0,48
2	11	11	10	10	10	10	52	51	50	0,41	0,41	0,41
3	16	15	13	9	11	12	49	49	47	0,51	0,46	0,53
4	8	8	9	8	9	9	44	52	47	0,36	0,32	0,38
5	8	9	10	8	9	8	41	40	37	0,39	0,45	0,48
6	10	10	10	9	10	9	36	39	39	0,52	0,51	0,48
7	8	8	8	7	8	8	44	45	45	0,34	0,35	0,35
DS	2,9	2,4	1,7	0,9	0,9	1,1	6,0	6,3	5,0	0,06	0,07	0,06
Average	9,8	10,2	10,1	8.7	9,4	9,1	43.5	44.5	43.4	0,42	0,43	0,44
Average Macrocycle	10			9,0			43,8			0,43		

IVSd: Interventricular septum in diastole. PWLVd: posterior wall of the left ventricle in diastole, DDLV: diastolic diameter of the left ventricle, EV: ejection volume or stroke volume. mm: millimeters

Table 5 shows echocardiographic variables and it is observed that the mean of the equipment for the three stages, regarding the values of the interventricular septum and the posterior wall of the left ventricle, showed a slight tendency to the upper limit, especially in the values of the interventricular septum; an athlete 14.3% of the sample presented in the measurements of the interventricular septum in most of the moments evaluated figures above those considered normal for athletes of these ages.

Regarding the diastolic diameter of the left ventricle, 3 athletes (42.8%) presented in the three stages, values lower than those considered normal, there was a collective inclination of the team to low measurements during all moments, evident in the mean of the macrocycle for this variable.

This trend towards high values of the interventricular septum and the posterior wall of the left ventricle and low values of the diastolic diameter of the left ventricle contributed to a high h / r index where 71.4% of all athletes exceeded the maximum values.

Table 6. Values of the echocardiographic variables: Ejection volume and ejection volume index.

Variables	EV (ml/latido)			EVI (ml/latido/m^2)
	Stages			Stages
Athletes	**GPS**	**GPE**	**SPE**	**GPS**
1	42	36	43	35,2
2	73	72	89	42,8
3	76	82	72	46
4	69	88	68	60.5
5	41	53	35	30,1
6	37	48	47	30,3
7	68	56	63	58
DS	17,1	17,9	18,8	11,9
Average	58	62.1	59.6	43.2
Average Macrocycle	59,9			43,5

Ml: milliliters, m2: square meter

When analyzing table 6, related to the ejection volume, it is shown that the team showed an average of 59.9 ml / beat, lower than what was established and expected for each stage, with 4 athletes from the study population 57.2 % who showed values lower than normal (65-80ml / beat). Regarding the ejection volume index, in a similar way, 5 athletes 71.4% of the total presented figures lower than desired in each preparation stage.

Table 1 shows that 4 athletes (57.2%) presented some type of heart rhythm disorder from the beginning of the general preparation, with the same results at the end of the special preparation, and the respiratory-type sinus arrhythmia is specified. Sinus bradycardia and sinus tachyarrhythmia such as those detected, elements that are common at this age, of which sinus bradycardia is an adaptation of endurance sports and is only detected in a male athlete with 5 years in the practice of this sport, being present from the beginning of the general preparation. These findings do not coincide with those described by Corrado (2012), who in his studies describe such significant values of sinus bradycardia for heart rate in long-distance athletes of 45-50 beats. / mto accompanied by a marked sinus arrhythmia, usually respiratory in nature.

Reflected in table 2, the heart rate values were evaluated in different training stages, not finding the expected decrease in the same as the training progressed, since only 1 athlete (14.3%) presented heart rate values below of 60 beats per minute in all stages of training. However, the authors themselves described in the previous paragraph, observed a decrease in baseline heart rate values in a group of young people after a 12-week training program.

Other studies carried out in the last 40 years with resting electrocardiograms in athletes describe a great variety of alterations attributable to sports training, particularly aerobic ones with increased vagal tone, the most frequent being sinus bradycardia between 50 and 85% of cases, sometimes with a frequency of less than 40 beats per minute (Fernández, 2015).

Wasfy et al. (2015) presented the electrocardiographic findings in 330 rowing athletes, of which 94% of them had one or more electrocardiographic patterns related to training, 51% of these were related to sinus bradycardia. Lower percentages were found in the research presented.

Regarding the PR interval in this table, one athlete (14.3%) developed first degree atrioventricular conduction disorder, which is similar to the results of Zehender Kaplinsky, Yahini, Hanne-Papro and Neufeld (1975) who found an incidence of first-degree atrioventricular block between 10% and 33% in similar studies.

Serra-Grima (2016) points out that the effect of training produces changes in the function of the atrioventricular node due to increased vagal tone, first degree atrioventricular block can occur in 33% of athletes, while second degree atrioventricular block degree is less frequent, and usually does not reach 1%. In the same way, the mean values described in this research are similar to those referred by Mathur (2018) who exposes an average of the PR interval of 0.16 seconds plus minus 0.01 seconds in sprinters and 0.18 plus minus 0.02 seconds in long distance runners.

In athletes, it is common to find discrete alterations in the duration and morphology of the QRS, when performing the analysis of the QRS complex described in the study and shown in Table 3, it was observed that the duration of the same in the different training stages was within normal values. When describing the morphology, the presence of incomplete blockage of the right bundle of the Hiss bundle was evidenced in two athletes, which represents 28.6% of the sample, the latter finding described as frequent in athletes at an early age of life (Uberoi , 2012).

Other investigations show nonspecific intraventricular conduction disorders with dented QRS in V1 (Fernández, 2015). (Wasfy et al., 2015).

Regarding the duration of the QRS complex, he partially agrees with Pérez (2004) who in his study showed a QRS of 0.09 plus minus 0.02 seconds without changes in the complex's morphology, in the same way Hernández O (2002) found QRS with an average duration of 0.06 seconds, not referring to other abnormalities.

In the results reflected in Table 3 of this study, all the athletes presented a normal QTc interval, similar to Peidro (2015) who, in his review article on the athlete's heart, states that the QTc interval is normal in the athlete. In general, the athlete's QTc has values considered in the upper limit of normality. Similar results were found by Carré (2015), when he studied this interval in endurance athletes.

Ventricular repolarization disorders are very frequent findings in athletes, which raise diagnostic doubts between the physiological and the pathological; Table 4 of the current study shows 57.2% of athletes with T wave alterations.

In the research carried out, there are deep negative T waves in V2, V3 and flattened T waves in V4, V5 and V6 and partially agree with those obtained by Hernández O (2002) and Pérez (2004) in their studies where they evidenced 27.6 % of athletes with negative T waves, 5.1% bimodal and 1.2% flattened T waves.

The appearance in Table 5 of values in the upper range of normality of variables such as the thickness of the interventricular septum and the posterior wall of the left ventricle, as well as those of the diastolic diameter of the left ventricle in lower ranges, such as were detected in this study during the three stages studied, should be carefully considered because they can be an indication of inadequate dosage, planning or application of training loads, where predominantly anaerobic work is being performed without the corresponding aerobic compensation (Rabassa, 2009).

The current research coincides with Géoffroy, Prohías, Castro, Mérida and García (2016) where in a study of triathletes they observed a progressive increase in the septal thickness and the posterior wall of the left ventricle, both suffered a gradual rise in their dimensions that slightly exceeded the values considered normal; In this study, the diastolic diameter of the left ventricle had an ascending linear increase as the training progressed, the current work differs from these results because as the training stages progressed, an inverse behavior to what was expected was verified.

These modifications suggest that there was an increase in intensity and strength work, also associated with difficulty in planning the work-rest regime; an inadequate planning of loads based on high intensities in addition to a short time of work with basic aerobic functional direction after each training session, what is indicated corresponds to bibliography such as Álvarez, Mollón, Mónaco and Villa (2015) regarding the subject they present the increase in wall thickness when the predominant work is with high intensity loads regardless of the preparation stage.

On the other hand, Mojena (2016) in his research that included 8 kayak schoolchildren in both sexes, obtained for the h / r index an average during the GPS and SPE of 0.35; its value in the current study does not coincide with those stated by said author.

Fuentes (2016) describes in 5 school long distance runners an average for the Ih / r in the 3 stages of preparation (GPS, PGE and SPE) of 0.42; 0.36 and 0.38 respectively, the present study does not show similarity with the last two stages analyzed.

When the mean of the equipment that was evaluated in the present investigation was analyzed, it is estimated that there was an increase in work intensities during all preparation stages, given the high value of the h / r index, a variable that is described in several studies Rabassa (2009), Venckunas (2008) increases when there is a predominance of work with higher intensities and it is indicative of having received high loads.

When analyzing the ejection volume (EV) and the ejection volume index (EVI) of the school long-distance runners in this research, shown in Table 6, it can be seen that there is a predominance of the deficit of aerobic capacity in athletes, reflected in the mean of the EVI variable at all times, which does not exceed 50 ml / beat / m2 of body surface, which indicates neglect of basic aerobic work, an aspect that is taken into account in several investigations, Rabassa (2009) Rabassa (2011), where basic aerobic work is valued during the preparation stages in which high intensities of training loads predominate.

In this study, lower than expected values were also found in the variables ejection volume and ejection volume index, evident in the equipment mean for both variables, throughout the macrocycle, which does not coincide with bibliographies (Rabassa, 2011) . (Mojena, 2016).

Fuentes (2016) during the study with school runners, in relation to the ejection volume and ejection volume index, obtained a mean of the equipment for each variable and in the three stages, lower than expected, the results of the present study are similar to those obtained in said research. In the present research, values similar to Rea (2017) were obtained in his study with school kayak practitioners in the stage studied (GPS).

When the functional direction of training has a predominance of high intensities with smaller volumes, an increase in wall thicknesses and a decrease or a slight increase in the diastolic diameter and volume of the left ventricle and the ejection volume and its respective volume index are observed, describing in these an increase in the values of the h / r index Rabassa (2009) and Rabassa (2011), which although they must be in the anaerobic aerobic equilibrium range, their values tend to be closer to 0.40, which suggests As in the case of the present investigation, no adjustments were made to the training loads, in addition to inadvertent basic aerobic work during the preparatory period, as shown by the results obtained in the echocardiographic studies, as part of the cardiovascular control of sports training.

Conclusions

1. The electrocardiographic changes found were: cardiac rhythm disturbances (sinus bradycardia and respiratory sinus arrhythmia), first degree atrioventricular block, incomplete right bundle branch block and minor ventricular repolarization disorders.

2. In the echocardiogram, the thickness of the interventricular septum and the posterior wall of the left ventricle showed values close to the upper limit of normality, contrary to the diastolic diameter of the left ventricle, which had a collective inclination in the equipment to low measurements during all the training stages, which contributed to a high h / r ratio in most athletes.

3. The ejection volume and the ejection volume index maintained values lower than those considered normal in the three training stages, which leads to the suggestion that there is an increase in work intensities throughout the macrocycle and a marked deficit of aerobic capacity, this suggests not having made adjustments to training loads and neglecting basic aerobic work during the preparatory period.

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