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The comparative evolution of functional cardiovascular adaptive changes in athlete and non-athlete students

Anca Dana Popescu
National University of Physical Education and Sports, Bucharest, Romania

Abstract. During physical effort the needs of oxygen and nutrients supplies of the tissues increase based to the intensity of the work performed. The changes that appear in the system represent adaptative reactions to the hemodynamic overloads in volume and pressure.
Cardio-vascular adjustment to effort implies modifications that appear in all the system's components – heart, blood vessels and blood. The changes aimed at both quantitative and qualitative aspects, as well as morphological and functional aspects. The adaptation capacity of the human body belongs to the natural evolution and it is conditioned by the differences of the individual responses of the body to the stimuli induced by the physical effort.
One of the main problems of the functional cardiovascular diagnostics, for trained or untrained persons, is to define the functional disorders, induced by the autonomic nervous system adjustments, from the organic disorders.
The hypotheses from which we departed in this research were that the organized and systematic practice of physical effort determines improvement of the neuro-functional cardiovascular response, and thus, the improvement of the individual's health. The dimensions of the functional adaptations depend on the level of demand to which the body is subjected, meaning the duration and the intensity of the effort. Research took place at the National University of Physical Education and Sports between 2012-2014 on two batches of students belonging to the Physical Education and Physical Therapy Faculties. The two batches were made up of 50 students, 25 girls and 25 boys from the structure of one full cycle and were studied annually in the first and second year of study. The tests used to assess the response of the cardiovascular system were the clino-orthostatic reflex and Schellong test.
As a conclusion the hypotheses was confirmed, the evolution of the average values of the pulse and blood pressure during the changes in body position was improved, more obvious for the first batch (physical education), especially in the second year.
Key words: *cardiovascular adaptation, clino-orthostatic reflex, heart rate, arterial pressure.*

Introduction

One of the main problems of diagnosis of cardiovascular function, both for the athletes and non-athletes, is that of the delimitation of functional disorders induced by nervous regulation, for the organics.
The human heart is located about 1.20 to 1.50 m above the point of plantar support, which makes that about 25% of the total blood volume to be below the heart, especially in the veins, which are 20-30 times more distensible than arteries.
It is known that abrupt changes in cardio-circulatory system determined by the change of body position from clinostatism to orthostatism leads to modifications in the blood distribution in the circulatory tree and in the venous supply to the right heart, the decrease in pressure to the reflex zones, decrease of the stroke volume by about 40% and decrease of arterial blood pressure.
All these effects are associated with gravitational changes in the circulatory system (1). In addition, the movement of blood leads to a stagnation of 600 ml in the veins below the heart level (2,3). These changes trigger reflex adjustments (4,5) by activating the sympathetic-adrenergic system and inducing pressure-type reactions (6-8) that leads to tachycardia and peripheral vasoconstriction in the skin, skeletal muscle and abdominal organs. Also, through positive inotropic action, the systolic flow growth (9,10). At the same time, stimulating baroreceptors in the venous system triggers the blood volume's adjusting reactions according to the functional situation (11).
Through the interaction of the two control systems is installed hemodynamic steady state (12). Under normal circumstances changing body's position in orthostatic position determine an increase of the

heart rate of 10 -18 /min, do not induce significant changes in systolic pressure (±10-15 mmHg) and slightly increase the diastolic pressure (±5-10 mmHg) (13,14). As the variations recorded between supine and standing are smaller, the reflex mechanism of cardiovascular regulation is more effective.

The hypotheses from which we departed in this research were that the organized and systematic practice of physical effort determines improvement of the functional cardiovascular response, and thus, the improvement of the individual's health. The dimensions of the functional adaptations depend on the level of demand to which the body is subjected, meaning the duration and the intensity of the effort and temporary interruption of systematic physical activity determines the decrease of the results obtained by training.

Material and method

The research took place at the National University of Physical Education and Sports between 2012-2014 on two batches of students belonging to the Physical Education (athletes) and Physical Therapy (non-athletes) Faculties. The two batches were made up of 50 students, 25 girls and 25 boys from the structure of one full cycle and were studied twice a year, in the first and second year of study. Initially, the two batches were relatively homogenous concerning the age and the body's level of adaptation to effort, because all of the candidates have to pass certain physical tests for the admission exam, and the predominance of practitioners of different type of sports among the candidates is approximately equal for the two faculties.

The tests used for the evaluation were clinoortostatic reflex, assessed by ECG recording, and Schellong test, by measuring heart rate (sec) and arterial pressure (systolic and diastolic).

After A. Gagea (15) the relevant parameter of clinoortostatic reflex is the dynamic relative deviation (DRD or K): $DRD=(HR_2 - HR_1)/HR_3$ HR_1 is the heart rate in clinostatism, HR_2 is the maximum heart rate immediately in the orthostatic position and HR_3 is the stabilized heart rate in orthostatic position, at about 40-50 seconds after changing position.

Results

Functional parameters were observed during a period of two years and were measured at the beginning and at the end of the academic year. The results were statistically processed, using indicators which allow a more complex analysis of the records (arithmetic mean, standard deviation). Next, the statistical processing used methods for comparing the average values of the parameters obtained in the two studied groups – ANOVA calculation method, in order to determine the existence of statistically significant differences between the registered averages, $p < 0.05$.

The recordings for DRD for the two annual evaluations show good average values for the girls in the first batch (physical education), with a noticeable improvement from 0,260 to 0,220, very close to the qualifier "good" for the students in the first year. For the girls of the batch II recorded average values were within the "good" rating, with the exception of the first year of testing, when values were misfit (0,300). The values for DRD dropped from the first to the second test as a result of systematic practice of physical effort (table 1). It is noticed the differences between the averages obtained by the two batches, especially for the students in the first year. In all cases the values obtained by the girls of the batch I (physical education) were lower, so better, than that of the girls of the batch II (physical therapy) (figure 1).

Table I. The evolution of DRD and Heart Rate during two years

Parameter (mean ± SD)	Year of study							
	I a		I b		II a		II b	
	P.E.	P.T.	P.E.	P.T.	P.E.	P.T.	P.E.	P.T.
DRD girls	0.26±0.01	0.30±0.02	0.22±0.01	0.26±0.02	0.21±0.01	0.21±0.01	0.18±0,01	0.20±0.01
DRD boys	0.25±0.01	0,28±0.02	0,22±0.01	0,23±0.01	0,21±0.01	0,23±0.10	0,18±0.10	0,19±0.10
HRCG	65.36±0.50*	72.96±1.00	64.34±0.41*	73.04±0.90	64.77±0.42*	73.20±0.97	62.68±0.37*	72.72±0.75
HROG	73.11±0.71*	88.00±1.25	71.02±0.52*	86.08±1.16	71.28±0.43*	87.04±1.10	68.94±0.34*	85.68±1.04
HRCB	65.47±0.47*	75.36±0.99	64.68±0.36*	74.40±0.84	64.79±0.34*	74.48±0.79	63.60±0.33*	73.36±0.82
HROB	73.58±0.61*	83.12±0.94	71.13±0.45*	82.16±0.93	71.51±0.37*	83.20±0.87	68.64±0.27*	82.00±0.82

*PE=Physical Education; PT=Physical Therapy; HRCG=Heart rate in clinostatic position–girls; HROG=Heart rate in orthostatic position – girls; HRCB=Heart rate in clinostatic position –boys; HROB=Heart rate in orthostatic position – boys; *p <0.05*

The boys from the two batches obtained good average values from the two annual testing, with the exception of the batch II - first year of study. In that case the average value was misfit (0,280) (table I). In all the circumstances there were registered lower average values at the second testing, so that result an improvement in cardiovascular autonomic control due to systematic exercise practice. In all the compared situations (fig. 2) there are no statistically significant differences between the obtained average values.

In Schellong test, the change of the position from supine to upright position increases the heart rate by 10-18 b/min, do not induce significant changes in systolic pressure (±10-15 mmHg) and slightly increase diastolic pressure (+5-10 mmHg), so that the differential pressure shows a rising trend. The nervous cardiovascular regulation is more effective as the variations of the values are smaller.

For the girls in the batch I the differences between the variations of the three parameters are within normal limits. For the heart rate (table I) the differences were between 7,75 /min and 6,26 /min, systolic blood pressure differences (table II) were between 6,85 mmHg and 5,87 mmHg and diastolic blood pressure differences (table II) were between 4,26 mmHg and 4,15 mmHg, which indicates a very efficient reflex regulation.

For the girls in the batch II the differences between the average values in the heart rate are standing between 14,56 min and 12,96 min, within the normal range of variation (table I). For the systolic blood pressure (table II) the differences were between 7,96 mmHg and 6,36 mmHg and for the diastolic blood pressure (table II) the differences were between 5,16 mmHg and 4.20. All values are within the normal reaction, which indicates an effective cardiovascular regulation.

There are significant differences (p=0) between the average values of the heart rate, both in clinostatic and orthostatic positions, for the two batches of girls at all determinations (table I). Figure 3 (a and b) reveal the differences between the groups, and that the values recorded by the students of the physical education are smaller, so better.

Regarding the systolic arterial pressure, in supine and upright positions, one can state that there are no significant differences between the average values obtained for the students of the two batches (table II), the results being similar for the two groups of girls (fig.5, a and b).

The diastolic arterial pressure in clinostatic position recorded significant differences between the average values in the second year, (table II, fig.6 a), while for the values in the orthostatic position there are no statistically significant differences, the values being similar in both groups of girls (table II, fig.6 b).

For the boys in the batch I was found that the differences between the variations of the three parameters between clinostatic and orthostatic positions are within normal limits. The differences in the heart rate (table I, fig.4, a and b) ranged from 8,11 /min to 5,04 /min, the differences in systolic arterial pressure (table II) varies between 5,01 mmHg and 4,03 mmHg, and the differences in diastolic arterial pressure (table II) were between 4,15 mmHg and 3,24 mmHg, which indicates a very effective autonomic cardiovascular regulation.

For students in batch II, the differences between the variations of heart rate between supine and standing positions were from 8.64/min to 7.76/min (table I). For the systolic arterial pressure (table II) the differences were between 6.96 m Hg and 5.76 mmHg and for diastolic arterial pressure (table II) were between 4.76-4.00 mmHg. All these values are within the normal range, which indicates a very efficient cardiovascular regulation.

In all the compared situations there are significant differences (p=0) between mean values of heart rate measured in supine and standing positions for the boys of the batch I (fig.4, a and b). In these cases it is found comparable improvement trend in average heart rate (pulse), especially for batch I (physical education).

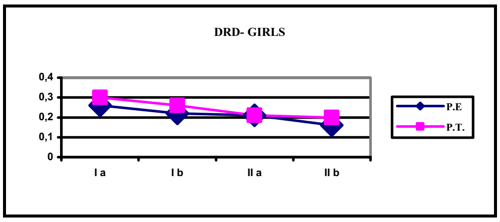

Figure 1. Evolution of the average values of DRD

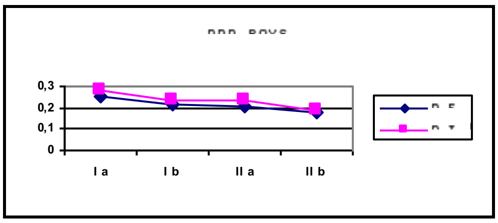

Figure 2. .Evolution of the average values of DRD

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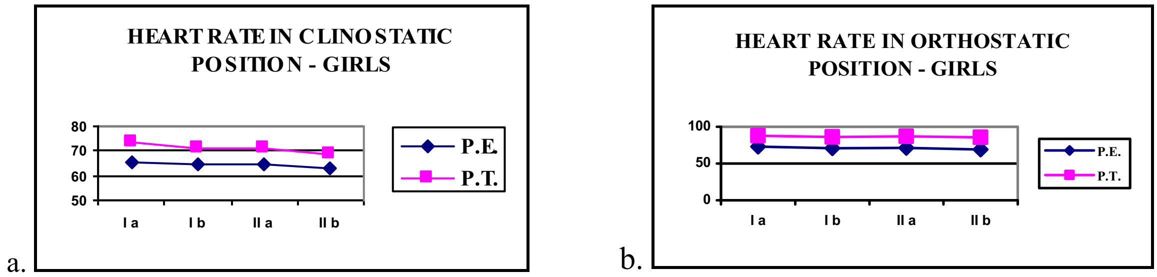

Figure 3.Evolution of the average values of the heart rate – girls

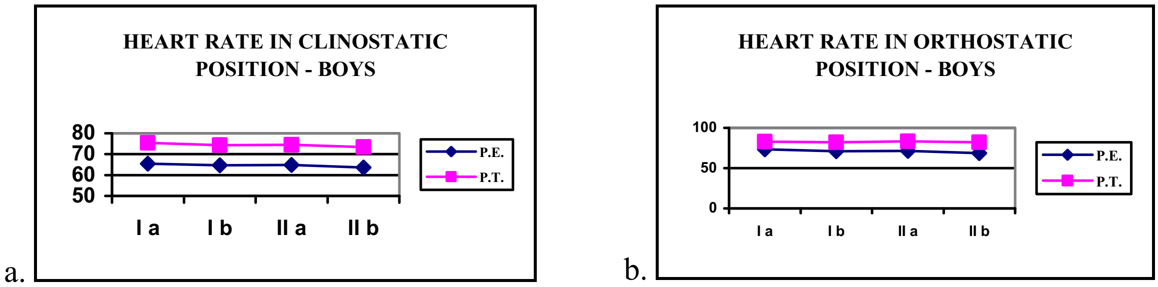

Figure 4. Evolution of the average values of the heart rate - boys

For systolic arterial pressure there are no significant differences between mean values for any of the compared situations, neither clinostatic nor orthostatic position (table II) (fig7).

For diastolic arterial pressure recorded in clinostatism average values at batch I are higher compared to those of the batch II (fig.8, a), with statistically significant differences between the two groups in the I and II year of study, both tests (p = 0). For the diastolic arterial pressure recorded in the upright position there is significant differences between the average values in the first year, at both testing, and in the second year at first

Table II. The evolution of blood pressure during two years

Parameter (mean ± SD)	Year of study							
	I a		I b		II a		II b	
	P.E.	P.T	P.E.	P.T.	P.E.	P.T.	P.E.	P.T.
SAPCG	121.40±0.47	121.88±0.71	120.30±0.35	120.00±0.59	120.700.27±	121.04±0.62	119.26±0.22	119.48±0.49
SAPOG	128.26±0.58	129.80±0.93	126.32±0.51	127.44±0.88	126.98±0.49	127.92±0.90	125.13±0.41	125.84±0.70
SAPCB	125.42±0.31	124.52±0.64	124.13±0.31	123.20±0.66	124.34±0.31	123.20±0.76	123.06±0.29	122.04±0.57
SAPOB	130.43±0.31	131.48±0.72	128.66±0.31	129.40±0.73	128.81±0.26	129.72±0.63	127.09±0.24	127.80±0.57
DAPCG	62.47±0.20	61.76±0.67	61.36±0.20	60.88±0.74	62.21±0.19*	60.64±0.53	60.74±0.20*	59.56±0.47
DAPOG	66.72±0.24	65.96±0.49	65.66±0.16	65.24±0.35	65.96±0.16	65.64±0.36	64.89±0.16	64.72±0.41
DAPCB	64.83±0.31*	61.36±0.56	63.57±0.28*	62.04±0.46	63.51±0.27*	61.68±0.32	62.70±0.25*	61.28±0.36
DAPOB	68.98±0.35	66.12±0.48	67.32±0.24	65.80±0.41	67.38±0.21	65.84±0.45	65.94±0.22	65.28±0.36

*SAPCG = Systolic arterial blood pressure in clinostatic position – girls; SAPOG = Systolic arterial blood pressure in orthostatic position – girls; SAPCB = Systolic arterial blood pressure in clinostatic position – boys; SAPOB = Systolic arterial blood pressure in orthostatic position – boys; DAPCG = Diastolic arterial pressure in clinostatic position – girls; DAPOG = Diastolic arterial pressure in orthostatic position – girls; DAPCB = Diastolic arterial pressure in clinostatic position – boys; DAPOB = Diastolic arterial pressure in orthostatic position – boys; *p<0.05* testing, the values being higher for students of the batch I (fig.8, b). In both groups there is a tendency of decrease in mean systolic and diastolic arterial pressure values, both in clinostatic and orthostatic positions throughout the two years, a result of the adaptation phenomena to effort.

Comparing the average values of the three parameters obtained from the two batches with the normal values shows that all the students fall into the normal reaction type, better results being recorded in batch I (physical education), in which the variations are smaller.

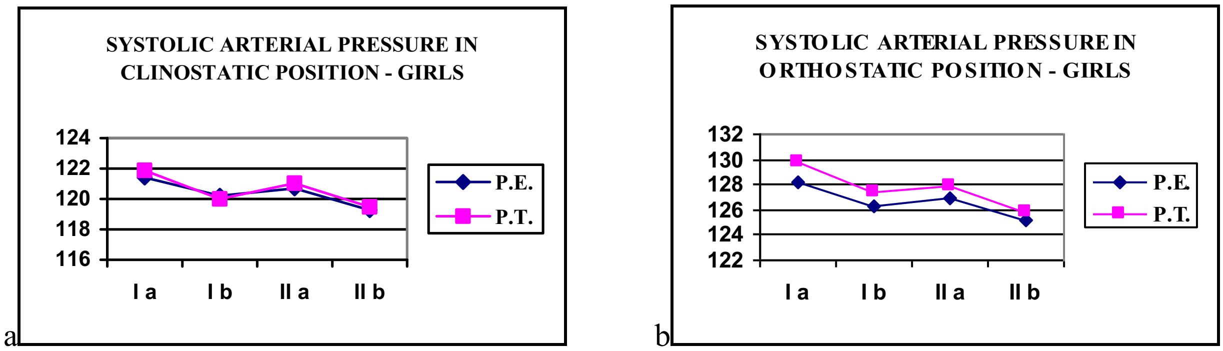

Figure 5. Evolution of the average values of the systolic arterial pressure – girls

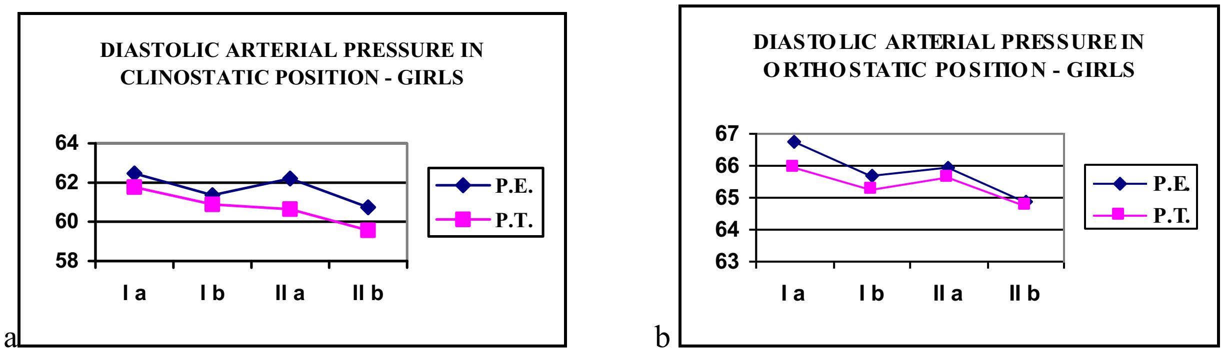

Figure 6. Evolution of the average values of the diastolic arterial pressure - girls

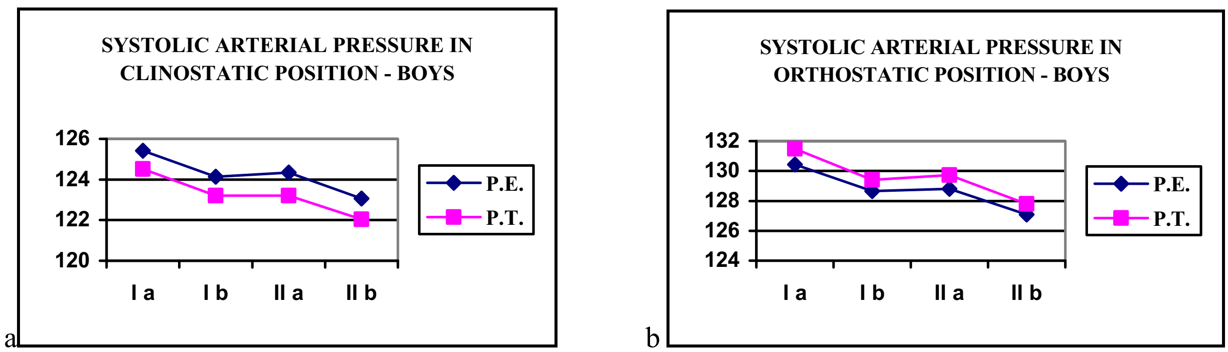

Figure 7. Evolution of the average values of the systolic arterial pressure - boys

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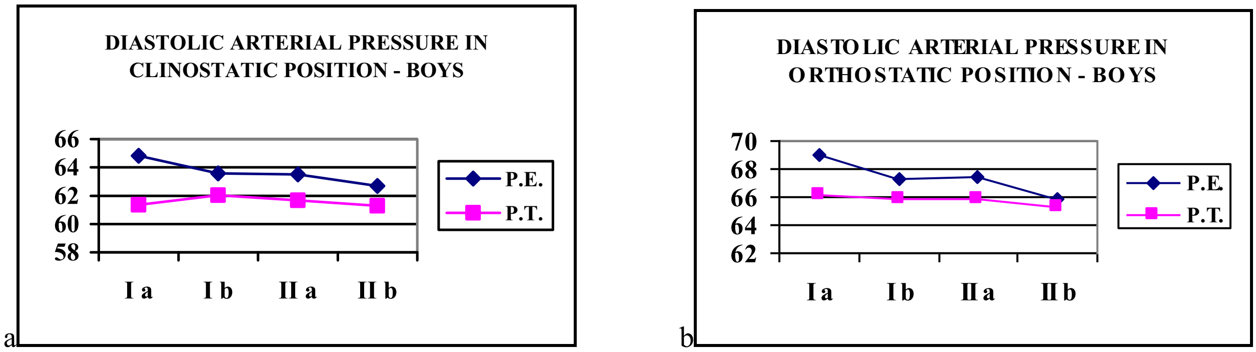

Figure 8. Evolution of the average values of the diastolic arterial pressure - boys

Conclusions

After the comparative study of the evolution of the average values of DRD and Schellong test parameters for students from the Physical Education Faculty (athletes) and from the Physical Therapy Faculty (non-atheles) during a period of two years, the following can be concluded: a clear improvement of the DRD at the end of the surveyed period compared to baseline, especially for the first batch (physical education); all the studied subjects fall into the normal type of reaction to clino-orthostatic test, the batch I recording smaller variations between the supine and standing positions; temporary interruption of systematic physical activity during the holidays has no significant importance on the adjustments made during the academic year.

These results confirm data from the literature according to which systematic exercise has positive effects on functional cardiovascular adaptive changes (16-18).

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Corresponding author
Anca Popescu
National University of Physical Education and Sports, Bucharest, Romania
Phone: +40723492284
E-mail: *ancadana_poescu@yahoo.com*

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