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The Effects of One Course of Perseverant Exercise on Functional and Structural Indices of the Heart in Pediatrics

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Abstract

Objective: Endurance training exercises improve function state of cardiac in long-term. The aim of this study was evaluation of cardiac indices include stroke volume (SV), cardiac output (CO), left ventricular ejection fraction (LVEF) in strength exercise.

Materials and Methods: Twenty boys with fourth and fifth grader after the manager's allowance and parent's consent was selected (10 patients as the case and 10 as the control groups), with average age, height and weight of 10.8 ± 6 years, 149 cm and 36 ± 8 kg, respectively. Perseverant exercises, structural (Left ventricle end-diastolic diameter [LVEDd], left ventricular posterior wall end diastole [LVPWd], left ventricular end-diastolic volume [LVEDV], left ventricular mass [LV mass]) and functional include LVEF, left ventricular cardiac output (LVCO), left ventricular stroke volume (LVSV) parameters. Height, weight, age, exercise intensity, healthy status, history of sports and body composition were recorded.

Results: Results indicated there was no significant difference between the case and control groups who had increased their SV index by 5.3% and 1.37%, respectively. The CO index was increase by 7.29 in case and a decrease by 6.9 in the control groups ($P > 0.05$). LVEF has no significant difference between groups. LVPWd showed an increase by 2.14 and 2.17 in the case and control groups, respectively ($P > 0.05$). Neither LVEDd nor LV mass did not show any significant difference in the control group, with a decrease by 2.26 and 0.31, respectively. Meanwhile the case group demonstrated a significant difference in the latter indices, with an increase by 6.78 ($P < 0.023$) and 12.64 ($P < 0.003$), respectively.

Conclusion: A course of perseverant exercises in children can effect on LVEDV, LV mass and LVEDd, but no change on LVEDV.

Keywords: Pediatric, Aerobic exercises, Heart function

Introduction

Based on the World Health Organization (WHO), cardiovascular diseases are the leading cause of death around the world. Most of those who die annually, suffer from these diseases than any other reason. In 2008, 17.5 million people died of this disease in the world (about 30% of all deaths). Interventional studies suggest that lack of physical activities were related strongly to these diseases (1,2). Regular physical activities are very important in decreasing the incidence of the morbidity and mortality of the cardiovascular diseases (3). Long-term exercises lead to a better physiologic status of the cardiovascular system (4). Prolonged high intensity perseverant exercises are associated with cardiac anatomical changes. Using new methods of technology such as echocardiography and some other imaging modalities, the changes can be documented (5). The body responds physiologically in a different manner to perseverant (aerobic) and strength (anaerobic), exercises (6-9).

All of the body including cardiovascular, respiratory, endocrine, nervous, motor and thermoregulation systems get adaptation in prolonged and severe static exercises (10, 11). These adaptations let the basic metabolic rate increase 20 times the rest value. Under such circumstances, cardiac output (CO) may increase about 6 times (8). The amount of the adaptation depends on age, gender, body size, fitness and the kind of exercises. Such cardiovascular adaptations after prolonged and severe exercises, have been reported in lots of studies, in adults (12-14). These adaptations consist of structural and functional changes. Severe exercises lead to lower heart rate, left ventricular (LV) hypertrophy, higher blood pressure, increased stroke volume (SV), CO and maximal O2 consumption (15,16). A few short and long term studies have proved the cardiorespiratory adaptations following aerobic exercises and before puberty. Review articles and meta-analysis can prove better these findings (15,16).

The aim of this study is to evaluate the effect of a course of 12-week perseverant exercises with a maximal heart rate of 55%-70%, on the structural (Left ventricle end-diastolic diameter [LVEDd], left ventricular posterior wall end diastole [LVPWd], left ventricular end-diastolic volume [LVEDV], left ventricular mass [LV mass]) and functional (left ventricular ejection fraction [LVEF], left ventricular

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cardiac output (LVCO), left ventricular stroke volume (LVSV)) parameters, in 10-12 years old children.

Materials and Methods

The study was done on 20 fourth and fifth grader boys (10 patients as the case and 10 ones as the control groups), having the average age, height and weight of 10.8 ± 6 years, 149 cm and 36 ± 8 kg, respectively. It was done after the manager's allowance and parent's consent. In this study, perseverant exercises, structural (LVEDd, LVPWd, LVEDV, LV mass) and functional include LVEF, LVCO, LVSV parameters, were considered as independent and dependent criteria, respectively. In addition, criteria such as height, weight, age, exercise intensity, healthy status, history of sports and body composition were taken into consideration as background ones. Criteria including age, gender, history of sports, any disease contraction, time-table and period of exercises, life-style, primary fitness of the participants and daily activities were under-control and those like anthropometric and genetic differences, climate, psychologic status, sport capabilities and initiatives were out of control.

Topographic and physiologic characters of the children of the case and control groups at different stages of investigation have been demonstrated in Tables 1 and 2.

The case group had a course of perseverant running for 12 weeks (three times a week with a 50%-70% maximal heart rate). The cardiac functional and structural parameters were evaluated using "My Lab 60" echocardiography, in the both groups. The results of the case and control groups (pre- and post-tests), at different stages, are shown in Tables 3 and 4, respectively.

In order to define the criteria, descriptive statistics was used (mean and standard deviation for quantitative data). Independent *t* test was utilized to demonstrate the randomized selection and normal distribution of the case group. Paired sample *t* test used to compare the intra-group average of criteria before and after the interventions. All the exams were done by SPSS 19, with a *P* value <0.05 (alpha 5%).

Results

The study showed no significant difference between the case and control groups who had increased their SV index by 5.3% and 1.37%, respectively. The CO index with an increase by 7.29 and a decrease by 6.9 in the case and control groups, respectively, without significant difference. LVEF displayed no significant difference in none of the groups with (the case) and without (the control) perseverant exercises. LVEDd, with an increase by 6.78 after perseverant exercises, had a significant difference ($P < 0.023$), in the case group but with a decrease by 2.26, without the exercises, in the control group no significant difference was detected. LV mass with an increase by 12.64 after perseverant exercises, had a significant difference ($P < 0.003$), in the case group but with a decrease by 0.31, without the exercises, in the control group no significant difference was detected. LVPWd showed an increase by 2.14 and 2.17 in the case and control groups, respectively, which indicated no significant difference. LVEDV showed a significant difference with an increase by 24.7 ($P < 0.002$), in the case (after 12 weeks of perseverant exercises) and no significant difference with an increase by 2.29 in the control groups, respectively.

Discussion

More information on the effect of exercise on the heart is in adult and research about effect of strength exercise on pediatric and adolescents has increased in last years (3,5,6). The safety and effectiveness of perseverant exercise are now well documented (17-22). Cardiovascular adaptations to sports training documented in adult athletes, in whom two morphological alterations are seen: eccentric and concentric LV hypertrophy (3). Training for most

Table 1. Topographic and Physiologic Characters of the Children of the Case Group

Variables	Stage	Mean	SD	Min	Max
Age (year)	Pre-test	10.9	0.24	10.6	11.3
	Post-test	11.2	0.24	10.6	11.3
Height (cm)	Pre-test	141	4.4	135	147
	Post-test	141	4.4	135	147
Weight (kg)	Pre-test	36.5	6.17	28.2	48
	Post-test	36.16	6.63	27.7	48.9
Heart rate rest (bpm)	Pre-test	84	9.23	72	100
	Post-test	70[a]	7.94	60	82
Blood pressure rest (mm Hg)	Pre-test	76.61	11.44	60.99	95.65
	Post-test	76.18	8.11	65.31	86.98
Fatty (%)	Pre-test	13.61	1.67	11.1	16
	Post-test	13.1	1.78	10.5	15.8
BMI (kg/m^2)	Pre-test	18.28	2.66	15.2	24.7
	Post-test	17.19	2.63	14.3	23.22
MaxO2 consumption (mL/kg/min)	Pre-test	44.92	3.03	38.7	49
	Post-test	51.03[a]	4.38	43.41	57.77

Abbreviation: BMI, body mass index.
[a] Significantly different compared to pre-test.

Table 2. Topographic and Physiologic Characters of the Children of the Control Group

Variables	Stage	Mean	SD	Min	Max
Age (year)	Pre-test	10.8	0.38	10.3	11.30
	Post-test	11.1	0.38	10.3	11.30
Height (cm)	Pre-test	143	5.15	136	152
	Post-test	143	5.15	136	152
Weight (kg)	Pre-test	37.31	7.04	29	48.5
	Post-test	37.59	6.46	30	47.4
Heart rate rest (bpm)	Pre-test	83	6.19	76	92
	Post-test	78[a]	6.32	68	90
Blood pressure rest (mm Hg)	Pre-test	83.88	12.16	59.32	101.31
	Post-test	80.11	12.11	65.98	98.98
Fatty (%)	Pre-test	13.84	2.39	10	17
	Post-test	13.83	2.35	10.1	17
BMI (kg/m^2)	Pre-test	18.06	2.60	14.6	22.7
	Post-test	17.92	2.63	14.7	22
MaxO2 consumption (mL/kg/min)	Pre-test	46.28	3.27	41.76	52.26
	Post-test	46.01	2.94	42.64	52.61

Abbreviation: BMI, body mass index.
[a] Significantly different compared to pre-test.

Table 3. Structural and Functional Cardiac Parameters in the Case Group Stages of the Study (Pre-test and Post-test)

Variables	Stage	Mean	SD	Min	Max
LVSV (cc)	Pre-test	45.7	10.98	30	68
	Post-test	49.4	10.80	39	71.76
LVCO (L/min)	Pre-test	4.39	1.13	3	5.8
	Post-test	4.71	1.26	3	5.54
LVEF (%)	Pre-test	71.3	8.21	58	82
	Post-test	67.8	8.71	54	76
LVEDd (mm)	Pre-test	38	5.55	27.5	45.1
	Post-test	40.66[a]	4.33	31	46
LVEDV (cc)	Pre-test	17.74	2.29	15.5	23.3
	Post-test	22.13[b]	3.74	18.2	27.79
LV mass (g/m^2)	Pre-test	77.74	12.97	56.3	95
	Post-test	88.16[c]	12.1	74.7	108
LVEDPWT (mm)	Pre-test	10.27	3.75	5.8	19.6
	Post-test	10.49	3.28	6.8	18.2

Abbreviations: LVSV, left ventricular ejection fraction; LVCO, left ventricular cardiac output; LVEF, left ventricle ejection fraction; LVEDd: left ventricle end diastolic diameter; LVEDV: left ventricle end diastolic volume; LV mass: left ventricle mass; LVEDPWT: left ventricle end diastolic posterior wall tissue.
[a] $P < 0.023$; [b] $P < 0.002$; [c] $P < 0.003$.

sports involves a combination of aerobic endurance and strength training, and so most athletes have increased LV diameter and wall thickness (5), although to varying degrees. LV mass is determined by various stimulus arising from the mechanical loads on the heart (17). Adaptations to LV structure and function appear to be dependent on the type, intensity and duration of exercise training increased venous return causes cell stretching, particularly in the endocardium. Increased after load (systolic arterial pressure) makes the myocardium work harder, and the effect is strengthened by higher heart rate. These hemodynamic stimuli trigger membrane receptors whose responses include signal transduction, leading to the release of growth factors, overexpression of inducible genes and activation of dormant genes (19).

The significant structural alterations in the ventricle, arising from the mechanisms that control ventricular remodeling, could be explained as a physiological response that results from balanced and proportional growth of myocytes and myocardial interstices; the functional changes are a consequence of the structural alterations. These, although more noticeable during exercise, are also detectable at rest (18). Most cardiovascular adaptations to sports training appear during adulthood (6). Studying such adaptations in children and adolescents is more complicated, as it is difficult to separate the effects of training from those of growth. Most studies have focused on selecting or identifying talent (16,20,21), largely ignoring dose-response relationships and the long-term significance of such changes. At the same time, the relatively light training loads encountered in these age-groups may in part explain the lack of clinical evidence of morphological

Table 4. Structural and Functional Cardiac Parameters in the Control Group Stages of the Study (Pre-test and Post-test)

Variables	Stage	Mean	SD	Min	Max
LVSV (cc)	Pre-test	52.93	13.09	30.17	73
	Post-test	52.55	10.72	30.1	70
LVCO (L/min)	Pre-test	4.78	0.83	3.22	5.9
	Post-test	4.45	0.68	3.42	5.6
LVEF (%)	Pre-test	69.4	10.76	54	89
	Post-test	65.3	6.89	51	76
LVEDd (mm)	Pre-test	36.63	8.33	16	45.1
	Post-test	35.8	6.31	20	43.6
LVEDV (cc)	Pre-test	18.27	3.4	11	22.3
	Post-test	18.69	2.87	13	22.54
LV mass (g/m^2)	Pre-test	74.85	10.92	60	90
	Post-test	74.62	9.55	61	91
LVEDPWT (mm)	Pre-test	9.2	2.3	6.8	15
	Post-test	9.04	2.02	7	13.8

Abbreviations: LVSV, left ventricular ejection fraction; LVCO, left ventricular cardiac output; LVEF, left ventricle ejection fraction; LVEDd: left ventricle end diastolic diameter; LVEDV: left ventricle end diastolic volume; LV mass: left ventricle mass; LVEDPWT: left ventricle end diastolic posterior wall tissue.

changes (20).

The characteristics of the young athletes themselves, in whom the process of biological maturation is not complete and thus autosomal regulation and catecholaminergic responses are weaker and the influence of growth factors and sex hormones are stronger, may also mean that the changes in the young are less marked than in adults (19).

The main objective of the present study was to evaluate the effect of aerobic training on LV morphology and function in Endurance-trained children and to demonstrate specific LV morphological adaptations compared with trained adults.

Absolute values of LV end-diastolic and end-systolic diameters, LV wall thicknesses, LV mass, SV, and CO were higher in adult men than in children. When those variables were scaled to body surface area (BSA), differences between trained boys and men were observed on LV wall thickness, LV mass, and SV as indicated, significant health benefits can be obtained by engaging in moderate amounts of physical activity on most, and preferably all, days of the week.

This study shows perseverant exercise in 12 years old children has full effect on LVEDV, LV mass and LVEDd, but no changes on LVPWd, LVEF, LVSV and LVCO. The lack of the changes in the latter group might be due to the period intensity, style deficiencies of the exercises and genetic factors. As a result, we can conclude that perseverant exercise can changes structural and function indices of the heart in children. Our finding of increased LVEDV, LV mass and LVEDd agrees with previous studies in adult (1-3). It was demonstrated that the endurance exercise in university students for 90 days, could increase LVEDV, LV mass and LVEDd significantly (23) and in addition it was indicated that after endurance exercise the heart rate and diastolic blood pressure was reduced significantly. Our results also demonstrated blood pressure and heart rate significantly decrease after perseverant exercise. Previously, it was shown endurance training led to LV hypertrophy along with its dilation and finally improvement systolic function (23). Researchers indicated there is no significant difference between trained athletes and sedentary controls in case of LVEF (24), our results in agreement with them and there was no significant changes on LV ejection fraction. Investigation of elite distance runners shown reduced LVEF, which it seems because of LV dilation in them (25). Endurance training improve diastolic function an d led to LVEDV increase and could increase LV preload and impress LV systolic function (23).

All in all, these results mainly support that, during resting conditions, the enhanced cardiac performance in endurance-trained children as well as adult men was mainly due to their higher LV filling.

Our results in agreement with the findings of Obert et al, and it was shown that the endurance training led to develop different left ventricular shape and left ventricular relaxation (3,5,6).

Conclusion

Therefore we suggest that similar studies be done, using “strength or combined” exercises at the same age range and in girls or at higher ages.

Ethical Issues

This study was performed after approving by the ethics committee of Tabriz University of Medical Sciences based on Declaration of Helsinki. Also, written informed consent was obtained from the patients.

Conflict of Interests

The authors declare that there is no potential conflicting interest for this study.

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