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ORIGINAL ARTICLE

Evaluation of blood pressures measured at the clinic and during exercise test in children

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ABSTRACT

Objective: In pre-participation examinations, an exercise test is required in addition to normal examination to evaluate cardiorespiratory functions and ensure safety during exercise if complaints related to effort or risk factors in the patient's personal and/or family history are observed. This study aimed to examine the blood pressure (BP) findings in clinical and exercise tests of children athletes who applied to our outpatient clinic.

Material and Methods: The histories, physical examinations, BP values, electrocardiography and echocardiography findings, and exercise test data of the patients who applied to our polyclinic between October 1, 2018, and September 30, 2019, for pre-participation examinations have been evaluated retrospectively.

Results: The study group consisted of 14 females and 36 males whose mean ages were 12.76±2.27 years and mean body mass index was 20.62±3.47. The electrocardiograms were normal. No cardiac dysfunctions were observed in echocardiographies. In exercise tests, the mean endurance time was 9.96±2.12 min, the maximum heart rate was 174.4±17.9/min, the maximum systolic BP was 169.34±28.52 mmHg, and the maximum diastolic BP was 86.82±20.21 mmHg. The BP of 16% of cases was above 200 mmHg.

Conclusion: In our study, exercise-induced hypertension was detected in some cases. The follow-up of these cases is important to determine future cardiovascular risks.

Keywords: Blood pressure, exercise test, hypertension, sport.

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INTRODUCTION

Hypertension, which is responsible for 12.8% of deaths in the world, is a significant problem.[1] Hypertension and atherosclerosis that start at early ages play a significant role in the basis of hypertension seen in adulthood. In relation to the increase in obesity and sedentary life which are important problems of our time, it is seen that the hypertension rates in children and adolescents are increasing. For the purpose of preventing hypertension problems that are probable to occur in the future, it is recommended to regulate nutrition, increase physical activity, and exercise regularly.[2] It is thought that exercise has positive effects on hypertension. Studies have reported that physical activity reduces cardiometabolic risks that are likely to occur at further ages.[3,4] Another study stated that there was a negative relationship between the cardiorespiratory form of children aged 6–10 years and their cardiovascular risk factors, while the cardiovascular risks in those with poor cardiovascular form increased in the follow-up of 2 years.[5]

For individuals to be able to exercise healthily and without causing risks, it is needed to investigate whether or not their cardiorespiratory functions are sufficient in their pre-exercise examinations. It is important to conduct additional tests that are seen necessary in the examinations before participation in exercise of those who have risk factors in their history and family history that may lead to complications while exercising. While the exercise test is one of such tests, its usage in children and adolescents has been medically accepted.[6–8] During exercise, blood pressure (BP) is physiologically increased. Its failure to increase or its decrease is a poor prognostic criterion in terms of cardiorespiratory function.[9] Excessive increase in BP values during the exercise test is defined as exercise hypertension.[10] Cases diagnosed with exercise hypertension have a higher risk of developing permanent hypertension in the future than those who have a normal increase in BP during exercise.[11]

Large numbers of children and adolescents are sent to pediatric cardiology outward clinic for the purpose of exercise participation examination. At our outward clinic, exercise tests are occasionally requested for children and adolescents, who have risk factors during pre-exercise examination (cardiac development at early age in the family, sudden cardiac death, genetic arrhythmia, etc.) or those who experience complaints of respiratory difficulty and chest pain during exercise test, to be able to exercise. This study examined the BP values and exercise hypertensions during exercise of cases for whom exercise tests were requested before participation in sports.

MATERIAL AND METHODS

This study was conducted with the decision of Ethics Committee dated March 3, 2021 and numbered 58. Cases sent to the Pediatric Cardiology Polyclinic for examination before participation in sports who did not have any chronic disease that would affect BP and cases for whom exercise tests were requested due to various risks they carried between October 1, 2018, and September 30, 2019, were included in the study by obtaining consent from their families. Anamnesis, physical examination, BP measurement, electrocardiography (ECG), and echocardiography (ECHO) and the results of exercise test conducted within the 1st week following examination were retrospectively derived from patient records and statistically and medically analyzed.

Clinical BP measurement was made after 5 min of resting (Mindray, PM 9000) with an oscillometric BP measurement device in a sitting position and from the right arm with the correctly sized cuff 3 times, and the average of the measurement values was taken. The BP values were assessed based on the age, sex, and height percentile tables of the 4th Report of the National High BP Education Program Working Group on High BP in Children and Adolescents.[5] BP values over the 95th percentile were accepted as hypertension. None of cases included in our study was using antihypertensive medication or medication that would affect BP.

The ECG of the cases was taken with a Cardiovit AT-102 plus (Schiller) device, while their ECHO was taken with a Vivid S6 (GE Healthcare Systems) device.

The exercise tests of the cases were carried out based on the Bruce protocol with a Schiller treadmill device by measuring their BP during resting and exercise, at the end of each level and in the recovery phase from the right arm with the correctly sized cuff. During BP measurement, simultaneous ECG recordings were also taken. The exercise time was ended when the desired maximum heart rate (HR) was reached, of with the request of the case due to fatigue. Among the results, values of higher than 200/95 mmHg were assessed as exercise hypertension.[9]

None of the children in the study group were diagnosed with diseases such as hyperlipidemia, diabetes, and chronical renal failure which might increase the risk for hypertension. None of them were taking any medication.

Statistical Analysis

The descriptive statistical (mean, median, minimum, maximum, and standard deviation) and Pearson's correlation analyses of the data obtained from the cases were carried out using the Microsoft Office Excel 2016 software. Kolmogorov–Smirnov test was used to determine data distribution, $p \leq 0.05$ was considered to be statistically significant. The relationship between the groups that were selected based on sex was analyzed by independent samples t-test using the SPSS 21.0 software.

RESULTS

The sample consisted of a total of 50 cases including 14 female (28%) and 36 male (72%) cases. Their mean age was 12.76±2.27 (9–17) years. Their mean weight was 54.26±16.05 (28–90) kg, height was 160.78±11.84 (132–185) cm, and body mass index (BMI) was 20.62±3.47 (16.07–29.70). BMI was under the 50th percentile in 20 cases (40%), within the 50th–95th percentile in 24 cases (48%), and over the 95th percentile in 6 cases (12%).

The number of cases with exercise durations of shorter than 1 year was 4 (8%), while the number of those who had been exercising for more than a year (1–9 years, mean: 2.89±2.04 years) was 46 (92%). Forty-six cases (92%) had a mean weekly exercise duration of 4.02±1.07 h (1–15 h). The remaining 4 (8%) cases were exercising for more than 10 h a week.

Seventeen cases played basketball, 13 played football, 7 swam and played water polo, 6 played volleyball, 3 did fitness, 3 did boxing and kickboxing, 2 did taekwondo and karate, 2 did aerobics, 1 played handball, and 4 took part in two different sports simultaneously.

Table 1: ECHO and ECG values

ECG	Mean	±SD	Min.–Max.
QTc (msec)	420.73	21.11	383–467
HR	79.00	16.00	57–110
ECHO			
LVDD (mm)	45.49	4.5	37–56
IVSD (mm)	8.93	1.32	7–11
LVPWD (mm)	8.79	1.58	6.11–13
LAD/Ao	1.18	0.13	1–1.47
EF (%)	65.7	4.09	59–74
SF (%)	35.25	3.28	31–43

ECG: Electrocardiogram; ECHO: Echocardiography; SD: Standard deviation; Min.: Minimum; Max.: Maximum; HR: Heart rate; LVDD: Left ventricular diastolic diameter; IVSD: Interventricular septum diameter; LVPWD: Left ventricular posterior wall diameter; LAD/Ao: Left atrium/aorta; EF: Ejection fraction; SF: Shortening fraction.

Table 2: Blood pressure values in clinical examination and exercise test

Clinical examination	Mean	±SD	Min.–Max.
Clinical systolic BP (mmHg)	113.92	11.17	95–137
Clinical diastolic BP (mmHg)	71.08	9.06	52–90
Exercise test			
Endurance time (min)	9.96	2.12	3.80–13.67
Max. HR (min)	174.4	17.9	140–205
Max. systolic BP (mmHg)	169.34	28.52	124–231
Max. diastolic BP (mmHg)	86.82	20.21	52–155

BP: Blood pressure; HR: Heart rate; SD: Standard deviation.

There were 20 cases (40%) who had risks in their history that would affect exercise (chest pain, shortness of breath, feeling of passing out during exercise test, and ventricular extrasystole in ECG), while there were 16 cases (32%) who had risk factors in their family history (early age myocardial infarction, sudden cardiac death, and rhythm problems in the family). According to the ECG findings, all cases had a sinus rhythm. ECG findings showed incomplete right bundle branch block in one case, sinus tachycardia in one case, and bradycardia in one case. There was no cardiac pathology that would affect sports in the ECHO findings. Two cases had patent foramen ovale, two cases had mild mitral valve deficiency, and one case mild left ventricular hypertrophy with athlete's heart (there was no other reason to cause hypertrophy). Our sample did not include any hypertensive case that was diagnosed or receiving treatment. The ECHO and ECG findings of our cases are shown in Table 1.

In the exercise test, the systolic BP was 200 mmHg or higher in 8 cases (16%), while the diastolic BP was 95 mmHg or higher in 10 cases (20%) and in the range of 90–95 mmHg in 5 cases (10%). The BP values were determined in our polyclinic examination and the data on the exercise test are shown in Table 2.

The data we obtained as a result of our study (age, weight, BMI, clinical systolic BP, clinical diastolic BP, endurance duration, maximum peak HR, maximum systolic BP, maximum diastolic BP, left ventricle end-diastolic diameter, interventricular septum diastolic diameter, left ventricle posterior wall thickness at diastole, left atrium aorta ratio (LAD/Ao), ejection fraction, and shortening fraction) were assessed based on the sexes, and the results are given in Table 3. As a result of the independent samples t-test in the one-by-one comparison of the data based on the sexes, in a 95% confidence interval, there were significant differences between the sexes in terms of BMI ($p=0.038$), effort duration ($p=0.024$), and LAD/Ao ($p=0.029$) (Table 3). There was no significant relationship between the sex variable and the other variables in Table 3 (age, weight, clinical systolic BP, clinical diastolic BP, maximum peak HR, maximum systolic BP, maximum diastolic BP, left ventricle end-diastolic diameter, interventricular septum diastolic diameter, left ventricle posterior wall thickness at diastole, ejection fraction, and shortening fraction).

When the correlation calculations of the data (age, weight, BMI, clinical systolic BP, clinical diastolic BP, effort duration, maximum peak HR, maximum systolic BP, maximum diastolic BP, left ventricle end-diastolic diameter, interventricular septum diastolic diameter, left ventricle posterior wall thickness at diastole, LAD/Ao, ejection fraction, and shortening fraction) were examined, it was found that there were weak relationships between age and exercise maximum peak HR ($r[48]=0.332$, $p<0.05$), exercise maximum systolic BP ($r[48]=0.423$, $p<0.05$), and maximum diastolic BP ($r[48]=0.151$, $p>0.05$). There were weak relationships between BMI and effort maximum peak HR ($r[48]=0.231$, $p>0.05$), maximum systolic BP ($r[48]=0.414$, $p<0.05$), and maximum diastolic BP ($r[48]=0.012$, $p>0.05$).

In two cases in whom ventricular extrasystole was detected in pre-sports examination and Holter ECG and had exercise tests requested, the ventricular extrasystole continued in one, and in the other, it disappeared in the exercise test and resting phase. No serious arrhythmia or ischemia was observed during the test.

DISCUSSION

The exercise test is the most important test in measuring and assessing the responses of the respiratory and cardiovascular systems to exercise. Its usage in children and adolescents has been medically accepted, and implementation protocols have been determined.[8] It might not be always easy to measure the capacity of oxygen used during exercise in children. The endurance duration in the exercise test and the oxygen capacity that is used as associated.[9] Endurance duration is accepted as a good indicator in showing the exercise capacity in children.[9] As indicated in the literature, in initial studies, the average endurance duration of 10.4 min at the ages of 4–5 increases to 14.1 min at the ages of 13–15.[7] However, based on different protocols, variations may be observed in the endurance duration of societies.[7] Considering endurance duration based on the sexes, it is seen that this duration is shorter in females than males. The mean endurance duration in our study

Table 3: Evaluation of variables according to gender

	Male (n=36)		Female (n=14)		p
	Mean	Min.–Max.	Mean	Min.–Max.	Sig. two tailed
Age (year)	12.89	8–17	12.43	8–17	0.553
Weight (kg)	56.08	28–90	49.57	25–80	0.176
BMI (kg/m²)	21.07	16.07–29.71	19.45	15.75–22.03	0.038
Clinical systolic BP (mmHg)	114.00	95–137	113.71	97–134	0.931
Clinical diastolic BP (mmHg)	70.89	52–89	71.57	54–90	0.800
Endurance time (min)	10.42	6.57–13.67	8.77	3.80–11.77	0.024
Max. HR (min)	172.67	140–205	178.86	154–195	0.222
Max. systolic BP (mmHg)	170.86	124–230	165.43	128–231	0.526
Max. diastolic BP (mmHg)	82.44	52–130	98.07	66–172	0.091
LVDD (mm)	45.65	37–56	44.56	40.9–50	0.424
IVSD (mm)	9.07	6.13–12	8.58	7–11.24	0.269
LVPWD	8.94	6.13–13	8.42	6.5–11.24	0.293
EF (%)	65.39	59–78	66.50	60–74	0.440
SF (%)	34.71	39–46	36.64	31–43	0.327
LAD/Ao	1.16	1–1.43	1.25	1.04–1.47	0.029

BMI: Body mass index; BP: Blood pressure; LVDD: Left ventricular diastolic diameter; IVSD: Interventricular septum diameter; LVPWD: Left ventricular posterior wall diameter; LAD/Ao: Left atrium/aorta; EF: Ejection fraction; SF: Shortening fraction.

was 9.96±2.12 min. There was a difference between the males and females in terms of the endurance duration (Table 3). While the mean endurance duration in the males was 10.42 min (minimum-maximum 6.57–13.67 min), that in the females was 8.77 min (minimum-maximum 3.80–11.77 min).

Measuring BP before the exercise test and during exercise is one of the required conditions of this test. It is needed for the BP to physiologically increase with exercise. Although its failure to rise or its reduction is among poor prognostic criteria,[9] excessive increase in BP and a systolic pressure of higher than 250 mmHg, and a diastolic pressure of higher than 125 mmHg are criteria for ending the exercise test. However, the precise limits of the exercise hypertension diagnosis criteria in the exercise test are under debate.[10] Studies have accepted the exercise hypertension limit as a systolic BP of 220 mmHg for adult male athletes and 200 mmHg for females. Different limits are reported for children regarding exercise hypertension. In children, BP may reach up to 180 mmHg during the continuation of the exercise test. It rarely exceeds 200 mmHg. The maximum diastolic pressure varies in the range of 51–76 mmHg, and mild increases are seen in diastolic pressure during exercise.[9] In our study, we determined the maximum systolic BP to be equal to or higher than 200 mmHg in 8 cases (16%).

It was reported that the increase in BP at the maximum effort in athletes who do high-performance exercise is higher than those who have sedentary lifestyle and the general population.[11] A study comparing a group of 26 adults exercising for more than 5 years and those that were not exercising defended the opposite of this case.[12] According to the study, although the resting BP was the same in both groups, the BP at the maximum exercise was lower in the exercisers.[12]

The reasons for the increase in exercise systolic BP are not completely known for now. It is debated whether this is a simple adaptation to exercise or connected to a subclinical cardiovascular pathology. It was reported that, in etiology, factors such as stiffness in large arteries, anomalies in the peripheral vascular structure, increased serum cholesterol, and insulin resistance may lead to this.[11,13] Nevertheless, as all these determinations are not on a degree to be able to sufficiently explain the situation, there is a need for more studies on this topic.

One of the other debated topics is the monitoring of cases with exercise hypertension. The probability of developing hypertension is 3.6 times higher in athletes whose BP values are high during exercise.[14] According to a study based on 7 years of follow-up, while hypertension developed by 3.5% in normotensive individuals, it developed by 13.5% in athletes that showed high BP.[14] A meta-analysis examined more than 46,000 cases in 12 longitudinal studies. According to the results of the meta-analysis, as a result of 15±4 years of follow-up, it was found that excessive increase in exercise BP increased the risk of cardiovascular events and mortality by 36% independently of the risk factors of age, sex, resting BP, and cardiac risk factors.[11] It was reported that serious arrhythmia is seen by 3% in the exercise test.[14] A noticeable arrhythmia was not observed in the exercise tests of our cases.

CONCLUSIONS

The exercise test was required due to the risk factors in the history or family history of our cases and complaints of cases. The exercise hypertension rates may be unique to this group. Nevertheless, this retrospective study is valuable in terms of showing that there is hypertension in children and adolescents who exercise. It requires investigation of this topic regarding athlete health and possible future cardiovascular risks.

Considering studies conducted in different countries, it is seen that test values in children and adolescents were different.[15–17] Comparing individuals who are exercising and those not exercising coming from different geographical regions who are homogenized for age, adolescence, type of sports and exercise times, conducting similar studies with a prospective, multicenter design, and broader samples, and establishment of exercise test normal values and percentiles for children will be useful. Moreover, assessment of cardiovascular risks in cases that develop exercise hypertension with long-term medical follow-up will contribute significantly in completing incomplete knowledge on this matter.

Statement

Ethics Committee Approval: The Zeynep Kamil Women and Children Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 03.03.2021, number: 58).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – NE; Design – NE; Supervision – NE; Materials – NE, ÇE; Data Collection and/or Processing – NE, İA; Literature Search – NE; Writing – NE; Critical Reviews – NE, ÇE.

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