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Research Article

# Is Clinical Blood Pressure Measurement Sufficient for Evaluating Blood Pressure in Children Doing Sports?

**Nurdan Erol[1]*, İlke Aktas[1] and Cigdem Erol[2]**

*[1]Health Sciences University Zeynep Kamil Gynecology and Pediatrics Training and Research Hospital, Pediatric Clinics, Dr. Burhanettin Ustunel Sokagi Uskudar, Istanbul, Turkey*

*[2]Istanbul University Informatics Department, Beyazit, Fatih, Istanbul, Turkey*

***Corresponding Author:** Nurdan Erol, Health Sciences University Zeynep Kamil Gynecology and Pediatrics Training and Research Hospital, Pediatric Clinics, Dr. Burhanettin Ustunel Sokagi Uskudar, Istanbul, Turkey.

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## Abstract

**Objective:** Cardiological examination is important in monitoring athletes' health. However, blood pressure values (BPV) measured may not always reflect actual BPV. In this study, a comparison of the BPV obtained in clinical and ambulatory blood pressure monitoring (ABPM) was made with the aim of investigating this difference.

**Methods:** The subjects were randomly selected from child athletes in our Pediatric Cardiology Outpatient Clinic. Physical examination, electrocardiography (ECG), echocardiography (ECHO) and ABPM were performed. The data was analyzed with the software Microsoft Office Excel 2016.

**Results:** The study consisted of 7 girls and 26 boys.Their ages were 13.52 ± 2.31 years. The mean weight was 64.52 ± 19.21 kg, the mean height was 167.61 ± 14.65 cm, and the body mass index was 22.38 ± 4.24. All ECG and All ECHO values were normal. The mean systolic BPV was 119.79 ± 12.47 mm Hg and diastolic BPV 72.55 ± 9.95 mm Hg in clinical examination. In the ABPM, the mean systolic BPV was 119.15 ± 10.45mm Hg and the mean diastolic BPV was 65.15 ± 6.78 mm Hg. In 5 of the subjects, blood pressure values were above the 95th percentile in ABPM readings. Masked hypertension was detected in 4 (12%) subjects and white coat hypertension was detected in 10 (30%).

**Conclusion:** It is argued that clinical measurements is not sufficient to evaluate blood pressure. Where blood pressure values are found to be high, it is recommended to use ABPM in order to detect acurate BPV.

***Keywords:*** *Sports; Blood Pressure; Ambulatory Blood Pressure Monitorization; Hypertension; Child*

## Abbreviations

BPV: Blood Pressure Values; ABPM: Ambulatory Blood Pressure Monitoring; ECG: Electrocardiography; ECHO: Echocardiography; BMI: Body Mass Index; PPV: Pulse Pressure Values; PPE: Pre-Participation Physical Examination; LVDD: Left Ventricular Diastolic Diameter; IVSD: Inter Ventricular Septum Diameter; LVPWD: Left Ventricular Posterior Wall Diameter; LAD/Ao: Left Atrium/Aorta; EF: Ejection Fraction; SF: Shortening Fraction; SD: Standard Deviation

## Introduction

Hypertension is an important health problem and one of the leading causes of death worldwide. It is known that 12.8% of all incidents of death are associated with hypertension [1]. In the USA, 32% of adults have hypertension and 1/3 of them have prehypertension [2]. Hypertension starting at an early age and associated atherosclerosis are factors effective in developing hypertension in adult age. Considering that BMI and obesity play a part in the development of prehypertension and hypertension, the observed increase in sedentary lifestyles and unhealthy eating habits over time and the rise in the associated obesity rates account for the higher incidence of early hypertension. Furthermore, atherosclerosis observed at an early age causes secondary events such as stroke, heart failure, myocardial infarction and kidney disease later in life [3]. Therefore, increased blood pressure is an important parameter for cardiovascular risk [3,4] and requires close monitoring in children and adolescents.

In order to reduce hypertension to prevent these complications, it is recommended to establish healthy nutrition habits, increase physical activity, and exercise regularly as stated in The Fourth Report [5,6]. Participation in sports is an increasingly more pronounced measure because of its assumed positive effects against hypertension [7].

Considering the close correlation between hypertension and sports, the importance of evaluating hypertension before participating in sports becomes relevant. Measuring blood pressure is also part of the standardized pre-participation physical examination (PPE) [4] performed before engaging in sports activities to check possible health issues they may bring about. Correct evaluation of blood pressure bears importance for the children who are to engage in the sports activities. In the scope of these tests, clinical blood pressure measurements are performed according to certain predefined procedures, but there are cases where these measurements are not sufficient. It may be that clinical measurements do not reflect actual blood pressure as a result of changes in blood pressure during the day due to different factors [8] and of various other circumstances such as the white coat effect, masked hypertension, or nocturnal hypertension [9]. Consequently, clinical blood pressure measurement is accepted to have 74.6% sensitivity and 74.6% specificity in detecting hypertension [10]. Contrary to the previously prevailing opinion, ambulatory blood pressure measurement is useful for an accurate assessment in children and adolescents where clinical blood pressure measurement is not adequate [11-16].

Many children and adolescents are referred to cardiology clinics for an examination before taking part in sports activities.

## Aim of the Study

The aim of this study was a comparative analysis of the blood pressure values obtained with clinical and ambulatory monitoring procedures as part of the physical and cardiological examinations prior to sports participation and as follow-up in children and adolescents referred to our outpatient clinic.

## Methods

Study subjects were randomly selected from among the individuals who were referred to the Pediatric Cardiology Outpatient Clinic for sports examination between 01.10.2018 and 30.09.2019, without a chronic disease to affect blood pressure and they were included in this study after obtaining parents' consent. In addition to obtaining their medical histories, physical examination, electrocardiography (ECG) and echocardiography (ECHO), we performed ambulatory blood pressure monitorization (ABPM) either on the same or the next day as the clinical blood pressure measurement.

Clinical blood pressure measurement was performed following a 5-minutes rest (Mindray, PM 9000) in sitting position with an oscillometric blood pressure measurement instrument and on the right arm, using a cuff adapted to the subject's arm. Following 3 measurements, mean values were taken. Blood pressure values were evaluated according to the age, sex, and height percentile tables provided in the 4th Report of the "National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents [5]. Values over the 95th percentile were accepted as hypertension. No patient was on antihypertensive drugs or any other medication that could affect blood pressure.

Electrocardiographs were obtained with the device Schiller, Cardiovit AT-102 Plus and echocardiographs with Vivid S6 (GE Heathcare Systems).

For the 24-hour blood pressure monitoring, the subjects were advised to continue their usual daily activities, but avoid heavy effort. Measurement was performed with a cuff adapted to and placed on the subject's right arm using the device Bravo 24-HR (Sun Tech Medical). Evaluation of the results was based on the "Normal Values of Ambulatory Blood Pressure in Healthy White Children," reported by Wühl., *et al.* [16] Values over the 95th percentile were accepted as hypertension.

The data obtained were analyzed with the software Microsoft Office Excel 2016. Based on these findings, correlation analyses were performed on the data set using descriptive statistical methods.

## Results

The data group consisted of 33 subjects, with 7 girls (21%) and 26 boys (79%). Their ages ranged from 13.52 ± 2.31 (7 - 17 years). The range of weight was 64.52 ± 19.21 (26.4 - 100 kg), height 167.61 ± 14.65 (131 - 192 cm), and their BMI range was 22.34% ± 4.24 (15.4 - 34.6).

As seen in table 1, among those with a family history of hypertension, duration of active engagement in sports activities was shorter than 1 year in 9.09% [3] and longer in 30.30% [10]. As for those who had no family history of hypertension, 15.15% [5] had a sports history of shorter than 1 year and 45.45% [10] had it longer than 1 year.

| History Yes (n) | | Family history of hypertension | | | |
|---|---|---|---|---|---|
| | | % | No (n) | % | |
| Sports activity (1 year) | Shorter | 3 | 9.09 | 5 | 15.15 |
| | Longer | 10 | 30.30 | 15 | 45.45 |

***Table 1:*** *Sports activity for shorter or longer than 1 year with family history of hypertension.*

No pathological findings were obtained in physical examination, ECG, or echocardiography. ECG and ECHO findings are presented in table 2. ECG findings were normal and none of the ECHO findings suggested structural cardiac disorder. Table 3 shows the blood pressure data obtained in clinical examination and ABPM.

| ECG | Mean | ± SD |
|---|---|---|
| Peak Heart Rate (min) | 84.42 | 20.73 |
| QTc (ms) | 409.15 | 18.70 |
| **ECHO** | | |
| LVDD (mm) | 45.78 | 5.12 |
| IVSD (mm) | 9.98 | 1.58 |
| LVPWD (mm) | 9.89 | 1.77 |
| LAD/Ao | 1.22 | 0.11 |
| EF % | 62.70 | 9.48 |
| SF % | 38.45 | 9.21 |

***Table 2:*** *ECHO and ECG values.*
*ECG: Electrocardiography; ECHO: Echocardiography; LVDD: Left Ventricular Diastolic Diameter IVSD: Inter Ventricular Septum Diameter; LVPWD: Left Ventricular Posterior Wall Diameter; LAD/Ao: Left Atrium/Aorta; EF: Ejection Fraction; SF: Shortening Fraction.*

| Clinical Examination | Measurement ± Standard Deviation | Minimum - Maximum Value |
|---|---|---|
| Clinical Systolic BP (mm Hg) | 119.79 ±12.47 | 90-145 |
| Clinical Diastolic BP (mm Hg) | 72.55 ± 9.95 | 43-90 |
| **ABPM** | | |
| Mean Systolic BP (mm Hg) | 119.15 ± 10.45 | 96-138 |
| Mean Diastolic BP (mm Hg) | 65.15 ± 6.78 | 54-88 |
| Mean Arterial Pressure (mm Hg) | 83.09 ± 7.37 | 68-104 |
| Mean Pulse Pressure (mm Hg) | 54.06 ± 7.55 | 36-72 |
| Mean Systolic BP Load (%) | 15.94 ±17.04 | 0-54 |
| Mean Diastolic BP Load (%) | 4.12 ± 8.96 | 0-46 |
| Systolic Drop in Sleep (%) | 10.78 ± 5.96 | -1.7-21.30 |
| Diastolic Drop in Sleep (%) | 15.43 ± 9.67 | -2.8-33.2 |
| Mean Daytime Systolic BP (mm Hg) | 123.48 ± 11.23 | 98-144 |
| Mean Daytime Diastolic BP (mm Hg) | 63.73 ±7.61 | 56-89 |
| Mean Daytime Arterial Pressure (mm Hg) | 86.97 ± 8.32 | 70-106 |
| Mean Daytime Pulse Pressure (mm Hg) | 54.88 ± 7.36 | 37-71 |
| Mean Nighttime Systolic BP (mm Hg) | 110.09 ± 10.15 | 83-136 |
| Mean Nighttime Diastolic BP (mm Hg) | 58.00 ±7.37 | 48-84 |
| Mean Nighttime Arterial Pressure (mm Hg) | 75.39 ± 7.32 | 60-101 |
| Mean Nighttime Pulse Pressure (mm Hg) | 52.09 ± 8.43 | 34-74 |

***Table 3:*** *Blood pressure values in clinical examination and ABPM.*
*ABPM: Ambulatory Blood Pressure Monitorization; BP: Blood pressure.*

In the clinical examination, blood pressure values in 11 of the cases were found above the 95th percentile. In 10 of them (30%), blood pressure was normal in ambulatory blood pressure monitoring and it was concluded that the hypertension observed in clinical evaluation was due to the white coat effect. In 4 (12%) of the normotensive subjects, blood pressure readings were above the 95th percentile in ambulatory blood pressure monitoring and this was evaluated as masked hypertension. On the other hand, 1 subject (3%) had high blood pressure in both measurements.

An examination of correlation values showed a moderately positive correlation between BMI and related measurements of the left ventricle (LVDD: 0.52, IVSD: 0.58, LVPWD: 0.63). And a moderately positive (0.68) correlation was established between the blood pressure values in clinical examination and ambulatory monitoring. Strong positive correlation was found between BMI and the pulse pressure values in the ambulatory Holter (nighttime pulse pressure: 0.73, daytime pulse pressure: 0.72, mean pulse pressure: 0.74); whereas there was a moderate correlation between systolic blood pressure values (daytime systolic pressure: 0.58, nighttime systolic pressure: 0.56, mean systolic pressure: 0.58). In the correlation matrix, it was observed that the values for sex, weekly and total duration of athletic activity, family history of hypertension, on the one hand, and the diastolic blood pressure, ejection fraction, shortening fraction, QTc, systolic dipping in sleeping, and night heart rate values obtained in the clinical examination, on the other, showed positive or negative, weak or very weak correlations.

## Discussion

Blood pressure measurement is part of the clinical examination of children and adolescents referred to the cardiology outpatient clinic before participation in sports activities; however, it is demonstrated that blood pressure assessment alone is not sufficient in many cases.

Therefore, ambulatory blood pressure monitoring (ABPM) was performed additionally to prevent possible bias in the values obtained in clinical measurements. As a matter of fact, hypertension was detected in 11 of the 33 study subjects in clinical measurements and 10 out of these 11 cases proved to be white coat hypertension during ambulatory measurements. On the other hand, 4 subjects that returned normal values in the clinical examination turned out to have masked hypertension in ambulatory measurement. This demonstrates the importance of ABPM against possible inaccuracies in clinical blood pressure assessment or in cases of overlooked hypertension, as well as detecting the types of underlying hypertension. Ambulatory monitoring is also beneficial in following possible cardiovascular problems that may develop as a result of various types of hypertension known as harmless: for instance, it is actually found that cases of white coat and masked hypertension are more likely to develop hypertension in the future as compared to those who are normotensive [9]. Furthermore, as a convenient and cost-effective [10] method, ambulatory monitoring can be widely used in the long-term follow-up of athletes. In the future, repeating this study with a larger group of subjects from various geographical backgrounds may ensure more accurate results.

## Conclusion

It is argued that a single clinical measurement is not sufficient to evaluate blood pressure. Where blood pressure values are found to be high, it is recommended to use ABPM in order to detect possible different types of hypertension.

Clinical examination may not always be sufficient in evaluating the blood pressures of children and adolescents who do sports, thus it would be a good measure to use ABPM to distinguish actual hypertension from other types of hypertension such as masked or white coat hypertension. Making this distinction will prevent the administration of unnecessary treatment in benign cases and will be useful during the follow-up of such cases as a means of determining possible risk factors that may lead to the development of hypertension in the future.

## Edit and Proofing

The article was edited/proofread by a native speaker who works at Glocal Translation, Istanbul/Turkey.

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## Conflict of Interest

Nurdan Erol, İlke Aktas, Cigdem Erol declare that they have no conficts of interests in relation to this review.

## Ethics Declarations

This study was performed in accordance with the standards of ethics outlined in the Declaration of Helsinki. All participants provided informed written consent (or written assent with parental consent, for minors) prior to participation in this study.

## Authors' Contributions

Nurdan Erol determined the subject of the research, examined the patients, prepared the data formats and wrote the article. İlke Aktas helped collect article data. Cigdem Erol made statistical analysis of article data and helped article writing.

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