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Research Article

CLASSICAL CARDIOVASCULAR AUTONOMIC FUNCTION TESTS IN SCHOOL CHILDREN OF URBAN POPULATION: A NORMATIVE STUDY

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Abstract

Almost all organs systems in the body are under the influence of autonomic nervous system (ANS) for maintaining homeostatic regulatory functions. Many of the present lifestyle related disorders like hypertension and obesity have their primary pathology in the homeostatic derangements. Childhood overweight and high blood pressure increase the risk of subsequent obesity and hypertension in adulthood. To the best of our knowledge there is no sufficient qualitative and quantitative data in childhood which restricts the use of this tool in scientific medical practice and in understanding the occurrence of these systemic diseases in near future. The plan of our study is to assess the classical cardiovascular autonomic functions tests in school children and to generate normative data to validate the subtle variations present in childhood for an earlier intervention.

Keywords: Autonomic Function Tests (AFT), Blood Pressure (BP), Heart Rate (HR)

INTRODUCTION

Autonomic nervous system (ANS) innervates almost all organ systems and is primarily involved with homeostatic regulatory mechanisms[1]. Many of the present lifestyle related disorders like Obesity, Diabetes and Hypertension have their primary pathology in the homeostatic derangements. The latent period of these diseases are very long and not surprisingly the pathology starts at early childhood[2]. It has been established by a number of investigators that Cardio vagal Baro receptor reflex sensitivity (BRS) starts to decline from the 20s and is reduced to almost zero in the 70s and 80s[4-6]. The Baro receptor reflex sensitivity in adults is still much below the level that has been reported for young adults[7,8]. The Cardiovascular autonomic function tests (CAFTs), totally a non-invasive tool has been scientifically well validated as evidenced by various clinical trials for assessing BRS. The non invasive cardiovascular autonomic function tests (CAFT) includes Heart rate (HR) and blood pressure (BP) response to standing, HR and BP response to deep breathing, HR and BP response to isometric hand grip[12,13]. Orthostatic challenge results in venous pooling which causes decrease in venous return. The decrease in the blood volume and blood pressure are sensed by high pressure and low pressure baro receptors. Signals from these receptors are carried in afferent fibres of the vagus and glossopharyngeal nerves to the brainstem (solitary tract nucleus of the medulla oblongata), which is part of the centre that regulates heart rate and blood pressure[1,9,13]. CAFTs can measure sympathetic and parasympathetic activity, sympathovagal balance (SVB) and subtle cardiovascular strain. The primary concern is to assess the integrity of the autonomic reflex arc and its maturation in the regulation of heart rate and blood pressure during various physiological perturbations. Unfortunately clinical scientific data in children are much lacking both qualitatively and quantitatively for a meaningful understanding of the pathophysiology and management of these diseases. Autonomic function data obtained from healthy children may serve as reference values for autonomic studies performed on young patients with cardiovascular disease[9-11]. Therefore, in the present study design we planned to assess classical cardiovascular autonomic functions tests in school children and generate normative data to qualify and quantify the subtle variations for addressing the aforementioned clinical problems in future in a scientific way for a preventive approach.

MATERIALS AND METHODS

The present study was conducted in Clinical Polygraph Laboratory of Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Pondicherry, India. Before commencement of the study, approval of JIPMER Scientific advisory Committee and Ethics Committee was obtained. Study groups were divided in to two groups via. Group I: 7-9 years children Group II: 10-12 years children. The children were recruited as aforementioned age groups from Kendriya Vidhyalaya no:

1, Central School which is located in JIPMER campus. Proper approval was obtained from school administration for the smooth conductance of the study. Written Informed consent and assent was obtained for recruiting the children by sending a consent form to parents through their children explaining them about the non invasiveness of the procedures done, the importance of the study and the benefits attained.

Selection of Subjects

Children were screened for any previous syncope and pre-syncopal attacks, Medical, surgical, and any neurological illness congenital disorders by doing preliminary systemic and neurological examinations by a physician. All recordings were done in recording room inside the school premises. Necessary arrangements were made for quiet and congenial environment with proper lighting and temperature conditions. The following parameters were recorded in all children according to the age category. Basal physiological parameters such as Heart rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Autonomic function test parameters such as Heart Rate and BP response to standing, response to deep breathing, response to isometric hand grip were recorded by explaining the procedure repeatedly and simultaneously. Before recording the cardiovascular parameters, the subjects were allowed to lie down on a couch in supine posture for 10 minutes and heart rate and blood pressure (BP) were recorded. Lead II ECG recording was done in supine resting position for five minutes. The subject was made to stand as quickly as possible with little effort for five minutes and BP and HR was recorded immediately, 2 minutes, and 5 minutes. Standard size paediatric BP cuff was tied on the left arm one inch above cubital fossa and the other end of the rubber tubing that inflates the cuff was attached to the CITIZEN non-invasive blood pressure (NIBP) monitor. Heart rate was calculated from ECG recording. The longest R-R interval (slowest heart rate) occurring about 30 beats divided by the shortest R-R interval (fastest heart rate) occurring about 15 beats after standing gave the 30:15 ratios [15]. Bio-harness HRV monitoring system is tied at the level of fourth intercostals space and the subject was instructed to breathe slowly and deeply (following the count of breathe in the order of 1 – 2 – 3 – 4 - 5, and breathe out - 1 – 2 – 3 – 4 – 5 and so on) at about six breaths per minute, 5 seconds each for inspiration and expiration. HR and BP Response to Isometric hand grip were recorded by using Hand grip dynamometer. The subject is instructed to grasp a dynamometer and sustain a fixed, isometric contraction for 3 minutes at 30% of maximum effort. The response to this test is subject to marked variability due to difficulty in standardizing muscular effort and particularly in children the procedure was properly done with good motivation.

Statistical Analysis

Data were analyzed using Student t test and Mann Whitney U test according to the normality of the distribution of data for cross sectional comparison of two age groups. For all measurements, Mean with SD was calculated. All statistical procedures were performed using SPSS 19.0 version. The P value of < 0.05 was considered to denote statistical significance.

RESULTS

The SBP was more in Group II when compared to Group I was around 96.1076 ± 9.663, 99.3875 ± 10.597 mm/Hg which is statistically significant (p value 0.026). The DBP is also found to be more in group II when compared to Group I was around 60.9692 ± 7.756, 63.4125 ± 6.498 mm/Hg (P value 0.0408). Mean arterial pressure between Group I and Group II was around 72.379 ± 69.961, 75.404 ± 6.615 mm/Hg which is also found to be significant (P value 0.0084). However, the pulse pressure is not significantly different across the two groups was around 34.923 ± 7.799, 35.975 ± 9.908 mm/Hg (P value 0.5390). The heart rate remains almost equal in both the groups. The value was found to be 83.30769 ± 11.974, 82.175 ± 12.479 Bpm. No specific variation was observed in heart rate. The systolic work of the heart as calculated by rate pressure product is found to be almost equal in both the groups. Finally, the group I have got more heart rate and fewer blood pressures whereas the groups II have lesser heart rate and more blood pressures. Autonomic function test parameters such as HR response to standing is observed more in group II when compared to group I the values are around 88.6649 ± 16.057, 91.48 ± 13.811 Bpm (P value 0.2156). HR response to immediate standing is found to be more in group II when compared to group I. The values predicted was around 122.6029 ± 13.035, 125.420 ± 13.337 Bpm (P value 0.2033) which is not statically significant. HR response after one minute of standing is found to be 91.052 ± 13.812, 92.195 ± 14.770 Bpm (P value 0.6343) which is statistically less significant. HR responds to 2 minutes after standing is found to be more or less equal in both the groups. The values predicted was around 99.8349 ± 12.394, 100.665 ± 12.636 Bpm (P value 0.6919), which is statistically less significant. No significant difference in 30:15 ratio and E: I ratio between the age groups.

DISCUSSION

The two groups categorised according to their age groups was studied and compared for various basal physiological and autonomic function parameters and we have evolved normative data for all the age groups between 7-12 years. Autonomic nervous system maturation has an initial rising phase in the foetal and early infant life[9]. The adult heart rate is almost achieved in the middle of the first decade due to the maturation of central and peripheral nervous system. The major finding in our study is that Mean arterial pressure steadily increases with advancing age, unlike the heart rates which are almost the same across the age 7-12 years. The increase in the blood pressures with ageing in this age group is attributed mostly to the increment in the cardiac output as the child grows. This can result in alteration in the dynamics of the low and the high pressure sensors resulting in altered firing patterns of these sensors[12]. From the findings of our study, we would like to propose that the sympathetic output steadily increases by ageing which is reflected by diastolic blood pressures. This is apparent by the statistically significant differences in the resting diastolic pressures between the two age groups[13]. The resting parasympathetic output can be studied by analyzing the resting heart rates[15]. The other major reason for the development of many cardiovascular diseases is the combination of abnormal direction and magnitude in the reactivity of ANS. So it is imperative to study the characteristics of reactivity tests[17]. The primary pathologies of ANS are rare but unfortunately abnormal reactivates of ANS are erroneously concluded as primary pathology of ANS itself.

Table 1: Resting basal cardiovascular parameters in two age groups of 7-9 years and 10-12 years

Variables	Group I (n = 65) Mean ± SD	Group II (n = 80) Mean ± SD	P value
SBP (mmHg)	96.1076 ± 9.663	99.3875 ± 10.597	0.026*
DBP (mmHg)	60.9692 ± 7.756	63 .4125 ± 6.498	0.0408*
Heart rate (Bpm)	83.30769 ± 11.974	82.175 ± 12.479	0.6749
PP (mmHg)	34.923 ± 7.799	35.975 ± 9.908	0.5390
MAP (mmHg)	72.379 ± 6.961	75.404 ± 6.615	0.0084*
RPP (%)	79.902 ± 14.677	81.980 ± 16.659	0.4321

From the above table it is clear that the basal cardiovascular parameters are more in group II when compared to group I and SBP, DBP, MAP which is statistically significant. Group I: 7-9 years children; Group II: 10-12 years children. Values expressed as Mean ± SD; Analysis done by Students' unpaired t-test. The p values < 0.05 was considered significant. * P < 0.05; ** P < 0.001; ***P < 0.0001.

Table 2: Comparison of heart rate response to orthostatic stress of 5 minutes supine rest in two age groups of 7-9 years and 10-12 years

Variables	Group I (n = 65) Mean ± SD	Group II (n = 80) Mean ± SD	P value
HR SUP (Bpm)	88.665 ± 16.057	91.48 ± 13.811	0.2156
HR MAX (Bpm)	122.603 ± 13.035	125.420 ± 13.337	0.2033
HR MIN (Bpm)	91.052 ± 13.812	92.195 ± 14.770	0.6343
HR 2 MIN (Bpm)	99.835 ± 12.394	100.665 ± 12.636	0.6919
Δ HR 2 Min (Bpm)	10.80 ± 5.95	8.87 ± 4.47	0.0274*
30:15 Ratio	1.3633 ± 0.1528	1.3811 ± 0.175	0.7762
E : I Ratio	1.4733 ± 0.1411	1.461 ± 0.105	0.385

VARIABLES

HR SUP (BPM) – HEART RATE AT REST IN SUPINE POSITION

HR MAX (BPM) - HEART RATE IMMEDIATE STANDING FROM SUPINE POSITION

HR MIN (BPM) - HEART RATE AFTER COMPLETE ONE MINUTE STANDING

HR 2MIN (BPM) - HEART RATE AFTER TWO MINUTES OF STANDING

From the above table autonomic function test parameters to orthostatic stress was found to be increased in Group II. Normal reference values for 30:15 ratio and E: I ratio was given. Group I: 7-9 years Children, Group II: 10-12 years children. Values expressed as mean ± SD; Analysis done by students' unpaired t-test. The P values < 0.05 was considered significant.* p < 0.05; ** p < 0.001; ***p < 0.0001.

Therefore, we would like to write with caution that the state of the ANS as documented in this study does not necessarily indicate any primary pathology of ANS. We would only like to present the picture of ANS in children and would like to appreciate the potential cause for the deviant re activities and not to conclude as deviant functioning of the ANS.[16]

Reactivity Tests

The HR and BP response to standing studied the re activities of both the limbs of ANS. We study the HR and BP changes simultaneously of which the HR response is finally funnelled through the PNS and the DBP changes primarily reflect and funnelled through sympathetic nervous system. The HR changes have the following parameters; HR supine, HR max, HR min, HR 2 minutes. In a typical biphasic HR response, all the four parameters are conveniently studied. The HR supine reflects the resting supine HR value. The HR max is the maximum HR achieved after assuming a n erect posture from recumbence. The HR min reflects the relative bradycardia after HR max. HR max is usually seen around the 15th beat. HR min is usually seen around 30th beat[15]. HR 2 minutes reflects the steady state HR after assuming erect posture. As per as the differences in the heart rates between supine and steady state erect values i.e. Δ HR 2 minutes, we found statistical significance between younger and older age groups. We would like to propose that homeostasis to an orthostatic challenge is achieved by more changes in the younger group than older group. However, though not statistically significant, 30:15 ratios are found to be slightly more in the older group. The 30:15 ratio depends on the initial rise in the heart rates and the relative bradycardia. Δ HR max is maximally contributed by parasympathetic nervous system withdrawal and backed by SNS. This initial parasympathetic withdrawal is found to be equal in both age groups and the cardiovascular reactivity milieu is not much different in these age groups as per Δ HR max considered. Therefore, we conclude the younger and older children have got same type of reactivity as 30:15 ratio does not differ significantly. The SNS reactivity is well appreciated by diastolic response to orthostatic challenge. This response almost exclusively reflects the sympathetic reactivity as blood vessel does not have parasympathetic innervations. From the findings of our study, we would like to conclude that the sympathetic output steadily increases by ageing. This is apparent by the statistically significant differences in the resting diastolic pressures between the two age groups. Proposed mechanisms include atherosclerosis in the vessels feeding the sensors, altered dynamics in the sensor transuding mechanisms by ageing, permissive and inhibitory role of other mediators, altered integrator activity and evolutionary remnant. In addition to this normal phenomenon, we would like to put forward the exaggerated reduction in the both cardiovascular performance and autonomic function output in children[18]. In this study, normal references values for 30:15 ratio and E: I ratio was presented in different age groups. No significant difference in 30:15 ratios between two studied groups with a marginal increase in older age group was observed.

CONCLUSION

From our study we concluded that Age is a definite controller of autonomic function test. Increase in ageing influences the cardiovascular autonomic maturation and modulation at rest as well as the autonomic reactivity to various challenges. The underlying cardio vascular response, autonomic response explains cardiovascular morbidity and mortality among the young children. Many of the present lifestyle related disorders like Obesity, Diabetes and Hypertension have their primary pathology in the homeostatic derangements. Childhood overweight and high blood pressure increase the risk of subsequent obesity and hypertension in adulthood. Autonomic function data obtained from healthy children might serve as reference values for autonomic studies performed on young patients with cardiovascular disease. So it is essential to examine cardiovascular autonomic function and this study design may help in addressing the aforementioned clinical problems in future in a scientific way for a preventive approach.

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