Original article

Evaluation of Parasympathetic Nerve Function by Heart Rate Response to Deep Breathing in Male Overweight Adolescents

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Abstract

Background:
Overweight among the adolescents has been observed as one of a serious public health challenge of the 21st century by World Health Organization (WHO)

Objectives:
To assess parasympathetic nerve function by heart rate response to deep breathing in male overweight adolescents.

Methods:
This cross-sectional analytical study was conducted from July 2018 to June 2019 in the Department of Physiology, Rangpur Medical College, Rangpur. After obtaining permission, subjects who would meet the inclusion and exclusion criteria were enrolled in the study after briefing them objectives of the study. A total number of 60 adolescents were selected, among them 30 were healthy male adolescents with normal weight (Group-A) and 30 were healthy male overweight adolescents (Group-B). The evaluation of parasympathetic nerve function in male overweight adolescents were done by performing deep breathing test. For statistical analysis unpaired t test was performed.

Results:
Heart rate response to deep breathing was significantly ($p<0.01$) lower in male overweight adolescents than those of male normal weight adolescents.

Conclusion:
The study concluded that decrease heart rate response to deep breathing test in male overweight adolescents indicate in the parasympathetic nerve dysfunction.

Key words: Overweight, Adolescents, Deep breathing test, Parasympathetic nerve function.

Introduction:

Overweight and obesity has been recognized as public health problem worldwide. Increasing trend of obesity among adolescents is a worldwide phenomenon and considered as one of the major public health challenges of the 21st century.[1] Overweight and obesity are nutritional disorders emanating from calorie imbalances. These disorders develop when calorie consumption surpasses calorie expenditure and the excess calorie gradually accumulates which later results into abnormal weight gain.[2] The World Health Organization (WHO) recommends the cut off values of body mass index (BMI) for the definitions of overweight and obesity for Asian populations which are as normal weight: BMI 18.5 to 22.9 kg/m2, overweight: BMI 23 to 24.9 kg/m2 and obese: BMI ≥25 kg/m^{2,3}

Adolescence is the period of transition between childhood and adulthood. There are physical, intellectual, social and emotional change occur during these period.[4] According to World Health

Organization (WHO), adolescence as the period of life between the age of 10 and 19 years.[5] Adolescence is a crucial part of their life and is considered to be one of the critical periods for the development of overweight or obesity.[6,7] According to UNFPA and WHO, adolescents currently comprise one-sixth of the world's population and over 90% of adolescents live in sub-Saharan Africa and in South and South-east Asia in 2017.[8] There were about 34 million adolescents in Bangladesh, who make up about 21% of total population.[9] The prevalence of overweight and obesity among adolescents has increased over the last three decades particularly in Asia.[2] In a recent study the highest prevalence of overweight was found in the United States and the lowest in Lithuania.[10]

All obese individuals are overweight but all overweight individuals are not necessarily obese.[3] Overweight and obesity negatively affects body strength, lower body mobility and daily activities.[11] Adolescents who are overweight or obese often experience significant social pressure, stress and difficulties accomplishing developmental tasks.[12] Autonomic nerve dysfunction also co-exist in addition to recognized complication caused by overweight or obesity.[13] The autonomic nervous system (ANS) is responsible for regulation and integration of internal organs functions.[14] Excess weight induces ANS dysfunction, which may be involved in the hemodynamic and metabolic alterations that increase the cardiovascular risks of overweight or obese individuals, i.e. hypertension, insulin resistance and dyslipidemia.[15]

The assessment of ANS requires recording the response of an end organ to physiological maneuvers. Changes in heart rate by a stimulus which reflects parasympathetic modulation. The simple, reliable and non-invasive deep breathing test based on cardiovascular reflexes is useful tool for evaluation of parasympathetic modulation of the heart.[16,17] Normally heart rate varies continually but this depends on an intact parasympathetic nerve supply.[15] When breathing at a normal rate, the heart rate varies with the phases of respiration. It accelerates during inspiration and decelerates during expiration, especially if the depth of breathing is increased due to fluctuations in parasympathetic output to heart. During inspiration, impulses in the vagi from the stretch receptors in the lungs inhibit the cardio-inhibitory area. The tonic vagal discharge that keeps the h eart rate slow decreases and the heart rate rises.[18] Heart rate variation to deep breathing significantly lower in overweight adolescents.[19]

Overweight and obesity related health problems are becoming quite common in our community.[20] Its health consequences ranges from increased risk of serious chronic conditions that reduce the overall quality of life to premature death.[21] Therefore, emphasis should be laid on early detection of the autonomic dysfunction in overweight adolescent population.[7] So, the present study has been designed to assess the changes of cardiac parasympathetic nerve function status in overweight adolescents.

Methods:

The cross-sectional analytical study was conducted in the Department of Physiology, Rangpur Medical College, Rangpur from July 2018 to June 2019. A total number of 60 healthy male adolescents, aged 17-19 years were included in this study from different areas of Rangpur districts, Bangladesh. Before perform the parasympathetic nerve function tests and collection of samples all the subjects were explained clearly about the objectives and the procedure of the study. Informed written consent of the study subjects were taken in easily understandable Bengali phrases. A standard questionnaire was filled up after taking history and thorough clinical examinations. All the study subjects were divided into two groups on the basis of their body mass index, among them 30 male normal weight adolescents were denoted as group A and 30 male overweight adolescents were denoted as group B. They were matched with age and socioeconomic condition. Study was carried out with prior protocol approved by the thesis protocol review committee and ethical committee of Rangpur Medical College, Rangpur. Obese and history of diabetes mellitus, hypertension, chronic renal failure, cardiac complication, obstructive lung diseases and liver diseases, tobacco users and alcoholics, any neurological disorders, psychiatric disorders (depression), endocrine disorders (thyroid, adrenal etc.), previous history of head injury and trained athletes were taken as exclusion criteria.

For calculation of BMI weight in Kg and height in m2 of each subject was taken by medical weighing machine and measuring tape respectively.

From the previous night up to the examination, they should not undergo any physical or mental

stress and not to take any sedatives or any drugs affecting central nervous system. Then the autonomic nerve function parameters were assessed by cardiovascular autonomic reflex tests using sphygmomanometer (mercury manometer) and ECG machine. Blood glucose, serum creatinine and serum alanine amino transferase level were measured to exclude diabetes mellitus, chronic renal failure and liver diseases respectively. FEV1 was also measured to exclude obstructive lung disease. Heart rate response to deep breathing test was conducted in a comfortable environment in the departmental physiology laboratory from 9.00am - 2.30 pm.

Resting Pulse Rate[22]

The subjects were asked to take rest for 10 minutes in supine position and radial pulse rate was recorded in supine position and expressed as beats/min. Three reading were taken and the average of the three was taken as the resting pulse rate.

Heart Rate Response to Deep Breathing[23]

The subject was asked to sit quietly and then asked to take breathe deeply and evenly at 6 breaths per minute (5 seconds in; 5 seconds out), thus completing one breathing cycle. Repeat this procedure for 3 times. An electrocardiogram was recorded throughout the period of deep breathing, with a marker used to indicate the onset of each inspiration and expiration. The maximum and minimum heart rate during each 10 seconds breathing cycle measured. The mean of the difference during 3 successive 10 seconds breathing cycle taken for calculating the heart rate variations.

Heart rate variation**:** maximum – minimum heart rate

Normal: ≥15 beats/min, Borderline: 11-14 beats/min, Abnormal: ≤ 10 beats/min

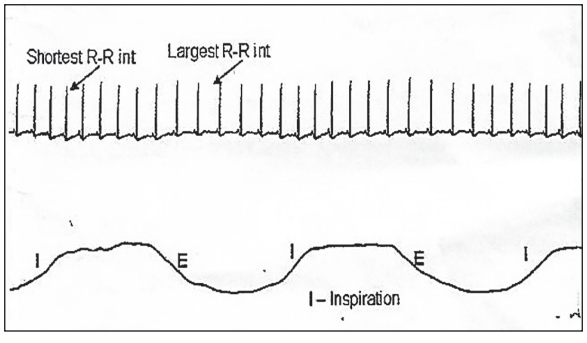


Figure-1: Representative tracing of deep breathing test[23]

All data were recorded systematically in a preformed history sheet and all statistical analysis was done by computer using the software SPSS-23.0 version for windows. Comparison between male overweight with normal weight adolescents were done by unpaired t tests. In the interpretation of results, <0.05 level of probability (p) was accepted as significance.

Result:

The mean±SD of age were 17.967±0.890 years in group A and 18.100±0.803 years in group B. The mean±SD of height were 1.639±0.049 m in group A and 1.646±0.058 m in group B. The mean ± SD of weight were 56.600 ± 4.415 kg in group A and 64.567±4.508 kg in group B. The mean ± SD of body mass index were 21.082 ± 1.271 kg/m^2 in group A and 23.784 ± .536 kg/m2 in group B.

The age and height were statistically non-significant between the groups but weight and BMI were statistically highly significant in group B than group A (Table–I).

Table-I: Showing mean ± SD of age, height, weight and body mass index of the study subjects in group A and group B

Variable	Group A (n=30)	Group B (n=30)	P value
Age-years	17.967± 0.89	18.100±0.80	0.990^{NS}
Height-m	1.64±0.04	1.65±0.05	0.995^{NS}
Weight-kg	56.60±4.41	64.56±4.50	0.000***
BMI (kg/m^2)	21.08±1.27	23.78±.53	0.000***
BMI range (kg/m^2)	18.5–22.9	23–24.9	

*** = p < 0.001

The mean ± SD of resting heart rate were 74.4333 ± 6.73480 beats/min in group A and 81.8000 ± 7.35035 beats/min in group B. The mean resting heart rate were significantly (p<0.001) higher in group B than A (Table –II).

Table-II: Showing mean ± SD of resting heart rate of study subjects in Group A and Group B

Variables	Group A (n=30)	Group B (n=30)	P value
Resting heart rate (beats/min)	74.43±6.73	81.80±7.35	0.002**

** =p <0.01

Normal Heart rate = 60 – 90 beats / min. 24

The mean ± SD of heart rate response to deep breathing were 20.9667 ± 3.59581 and 18.8667 ± 2.56949 beats/min in group A and group B respectively

Table-III: Showing mean ± SD of heart rate response to deep breathing of study subjects in Group A and Group B

Variables	Group A (n=30)	Group B (n=30)	P value
Deep breathing (beats/min)	20.9667±3.59	18.8667±2.56	0.009**

** = $p < 0.01$

Discussion:

The present study was carried out to observe the changes in heart rate response to deep breathing test in between healthy normal weight and overweight male adolescents. BMI was calculated to differentiate normal weight and overweight individuals. In overweight male adolescents, mean value of heart rate response to deep breathing was significantly ($p<0.05$) lower than normal weight male adolescents. The finding is in consistent with that of some other investigators.[17,25,26] In contrast some other researchers did not find any significant difference in overweight and normal weight adolescents.[27,28]

The exact mechanisms involved for the impairment of autonomic nerve functions in male overweight adolescents cannot be established clearly. Changes in the autonomic nervous system activity begin in the overweight and may become more prominent in the obese thus indicating increased cardiovascular risk.[29] The result of our study suggested that with increased body mass index, modification in the autonomic nervous system and the frequency of involvement of cardiovascular autonomic function impairment also increased in overweight adolescents.

Gradual development of insulin resistance in target tissues with the beginning of excess weight gain in overweight is responsible for subsequent development of hyperinsulinemia. This hyperinsulinemia has got a role in low cardiac vagal activity. But several researchers made various suggestions such as high insulin level or insulin resistance might cause damage to autonomic nerves at any level of their reflex arc, insulin resistance might cause deterioration of microcirculation in many tissues including nerves which might lead to neural ischemia and thereby damage of cardiac parasympathetic nerve terminals occur at the level of cardiac muscle or vascular wall.[13]

From this above discussion, it has been shown that significantly lower values of heart rate response to deep breathing indicates parasympathetic impairment or decreased vagal tone may occur due to decrease baroreflex activity in male overweight adolescents.

Conclusion:

After analyzing the results of the study, it can be concluded that decreased parasympathetic nerve activity in male overweight adolescents, as evaluated by heart rate response to deep breathing strongly indicates the need for the early holistic care of these adolescents to allow them to avoid the onset of future complications. However further studies with large size samples of different age groups and comparison between sexes are recommended for more precise evaluation to aid in identification of those prone to weight gain and are at higher risk of cardiovascular complications.

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