

Effect of Isometric Handgrip Exercise Training on Cardiac Autonomic Activity in Offsprings of Hypertensive Parents

Ashwani Sharma^{1*}, Rajesh Misra², Kiran Singh³

¹Ph.D. Scholar, Department of Physiology, Subharti Medical College, Meerut–250005, India

²Professor, Department of Physiology; Principal, Shridev Suman Subharti Medical College, Dehradun–248007, India

³Professor & Head, Department of Physiology, Subharti Medical College, Meerut–250005, India

Original Research Article

*Corresponding author

Ashwani Sharma

Article History

Received: 03.10.2018

Accepted: 12.10.2018

Published: 30.10.2018

DOI:

10.36347/sjams.2018.v06i10.035



Abstract: Hypertension is a major silent disease affecting young people because of their hereditary connections and sedentary lifestyle. Hence, the need for change in the lifestyle to prevent future morbidity becomes important. The present study was planned to evaluate the effect of 12-weeks isometric handgrip (IH) exercise training on cardiac autonomic activity in offsprings of hypertensive parents. 50 subjects of age group between 18 to 26 years with positive family history of hypertension were included in the study and isometric handgrip (IH) training was imparted to them 4 days a week for a total of 12-weeks. The exercise training protocol consisted of four sets of 3 minutes IH contractions with dominant arm at 30% of the maximal voluntary contraction (MVC) and each set was separated by 3 minutes rest pause. Cardiovascular and Heart Rate Variability (HRV) parameters were recorded before and after 12-weeks of IH training. The pre and post-exercise training data was compared by student paired t-test and the level of significance was set at $P < 0.05$. It was observed that the cardiovascular parameters (heart rate and blood pressure) of the subjects were reduced after IH training but only systolic blood pressure was reduced significantly. The time domain parameters of HRV were found to be insignificantly high after exercise training. Among frequency domain parameters, the mean values of LF and LFnu were significantly decreased whereas mean values of HF and HFnu were insignificantly increased 12-weeks post-exercise training. The LF/HF ratio also decreased but not significantly. IH exercise training resulted in improvement of cardiac autonomic activity in the form of decreased sympathetic activity and increased parasympathetic activity in offsprings of hypertensive parents. A lifestyle change such as isometric exercise may play a role in preventing hypertension in these genetically predisposed individuals.

Keywords: Handgrip Exercise Training, Heart Rate Variability, Hypertension.

INTRODUCTION

Hypertension is a major public health problem due to its high prevalence worldwide. According to World Health Organization (WHO), approximately one billion people are suffering from hypertension resulting in 7.1 million deaths each year [1].

Further discouraging is the prospect that the chances of hypertension are projected to increase 60% by 2025 and it is undeniable that the hypertension is linked with an increased risk of various cardiovascular diseases [2-3].

Our previous study showed that cardiac autonomic imbalance in the form of increased sympathetic activity and decreased parasympathetic activity was more in offsprings of hypertensive parents than offsprings of normotensive parents at resting level. So, the risk of developing hypertension in these

genetically predisposed individuals was estimated to be higher than offsprings of normotensive parents [4].

As a preventive measure, the offsprings of hypertensive parents should aim to improve their cardiac autonomic activity i.e. decrease in sympathetic activity and increase in parasympathetic activity to prevent hypertension in their later stages of life.

Physical exercises bring about changes in hemodynamics of cardiovascular system [5]. Isometric handgrip exercise is a form of static resistance exercise in which no noticeable change occurs in the length of muscle fiber but tension within the muscle fiber increases [6]. This exercise results in compression of blood vessel and occlusion of blood flow to active muscle [7].

The ability of isometric exercise to occlude blood flow at low intensity (~20% Maximum Voluntary

Contraction) initiates a powerful pressure response, known as metaboreflex. This reflex occurs due to the vasoconstriction of inactive vascular beds in an attempt to restore blood flow to active muscles [8-9].

The heart rate and blood pressure responses to isometric exercise are influenced by the force of contraction [10], size of contracting muscles [11] and the duration of muscle contraction [12].

Handgrip spring dynamometer is an effective and widely popular instrument in research areas, used to institute isometric exercise training. Till now, no 12-week study has yet assessed the effect of isometric handgrip training on cardiac autonomic activity in offsprings of hypertensive parents.

AIM AND OBJECTIVES

The present study was undertaken to evaluate the effect of 12-weeks of isometric handgrip exercise training on cardiac autonomic functions in the offsprings of hypertensive individuals.

MATERIALS AND METHODS

The ethical clearance was obtained from the Ethical Clearance Committee of Swami Vivekanand Subharti University, Meerut (U.P), India and the study was conducted in the Research Laboratory of Physiology Department of Subharti Medical College, Meerut (U.P.). After taking written informed consent, a total of 50 students (aged between 18 to 26 years) studying at undergraduate level in Swami Vivekanand Subharti University, Meerut (U.P.) were recruited for the study. All subjects were normotensives and a positive family history of hypertension was considered to be present when at least one of the parents was hypertensive. The parental hypertension was identified by evidence of antihypertensive treatment in their medical history/ record. A detailed history and general examination was done to exclude subjects satisfying exclusion criteria.

Exclusion criteria

Subjects with any clinical signs and symptoms related to cardiovascular, respiratory, renal, endocrine disorders or taking any medications that affect autonomic nervous system physiology, practicing yoga or exercise, orthopedic problems such as recent fractures, joint and muscle pathologies, physical disability, smokers and alcoholic were excluded from the present study.

Experimental protocol

The subjects were asked to report in the Research Laboratory of Physiology Department between 9-11 a.m. after having light breakfast without tea, coffee or caffeinated beverages such as coke etc. at least 2 hours prior to recording. The Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood

Pressure (DBP) and Heart Rate Variability (HRV) were recorded as baseline parameters.

The subjects were asked to hold the handgrip dynamometer (Inco, Ambala) comfortably in their dominant hand. They were instructed to press the handle with maximum possible effort and maintain for atleast 5 seconds for obtaining Maximum Voluntary Contraction (MVC). The value of MVC was determined as the highest value obtained in three attempts, separated by 1 minute rest period.

Subjects were trained to perform sustained handgrip at 30% of MVC for 3 minutes (1 set). Four such sets separated by a rest period of 3 minutes were carried out. This protocol (Ray & Cassaro) was followed for 4 successive days a week for a total of 12-weeks.

On the next day of completion of this 12-weeks training schedule, all the above mentioned parameters were recorded again. Following this, pre and post-exercise training parameters were compared to evaluate the effect of IH exercise training.

Recording of Heart Rate and Blood Pressure

The HR and BP were measured through automatic heart rate and blood pressure measuring machine (Accusure TD 3127, Taiwan). The BP cuff was tied just tight (neither too loose nor too tight) on the right arm approximately 2 - 2.5 centimeters above from the cubital fossa. It was ensured that the BP cuff was at the level of heart. After 5 minutes of rest in supine position, the "start" button of machine was pressed that automatically inflated and deflated the BP cuff. HR, SBP and DBP were noted from the display screen of the machine. For each subject, HR, SBP and DBP were recorded in same arm thrice, keeping an interval of 5 minutes between the recordings. Mean of the three recordings was considered for each parameter.

Recording and assessment of Heart Rate Variability

HRV of subjects was measured with digitalized polygraph machine "Polyrite-D" Version 2.4 (Recorders and Medicare Systems Private Limited, Chandigarh, India) as per the standards laid by Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology [22]. The subject was asked to lie down on a couch adjacent to the Polyrite-D machine. The metallic electrodes were attached to left arm, right arm and left leg. After the rest of 5 minutes, ECG was recorded in Lead II for 5 minutes at a speed of 25mm/s & voltage of 10mm/mv. The ECG data was used for analysis of HRV. High and low frequency filters were set at 99 Hz and 0.1 Hz respectively.

Power spectral analysis of ECG data was done using Fast Fourier Transformation (FFT). The analogue to digital conversion of the data was done using 14-bit A/D Converter with the sampling frequency of 256 Hz.

Artifacts and ectopic beats were edited by the software from the recorded 5 minutes of ECG. The R wave detector detects remaining R waves in QRS complex of recorded data and the time domain indices were derived from the measurement of intervals between normal beats (normal-to-normal) successive in a series of continuous time that can be evaluated by statistical or geometric patterns. Time domain indices such as Standard Deviation of Normal-to-Normal intervals (SDNN), Root Mean Squared Standard Deviation (RMSSD), Number of N-N intervals with differences more than 50 milliseconds (NN50) and Percentage of number of N-N intervals with differences more than 50 milliseconds (pNN50%).

Similarly, the R-R tachogram of 256 seconds of R-R waves were plotted and analyzed by the power spectral density. In the frequency domain analysis, Low Frequency band (LF, 0.04–0.05Hz) and High Frequency band (HF, 0.15–0.4Hz.) were used. By frequency domain analysis, the following parameters were obtained : Low Frequency power (LF power), High Frequency power (HF power), Low Frequency in normalized units (LFnu), High Frequency in normalized units (HFnu) and ratio of Low Frequency to High Frequency (LF: HF ratio).

Statistical analysis of the data

Data was presented as Mean ± Standard Deviation (SD). The comparison between pre and post-exercise training values were done by applying

student’s paired t-test. The data was analyzed by using GraphPad Prism 5 software version 5.03 and statistical significance was set at P< 0.05 level.

RESULTS

Table 1 shows that the mean values of HR, SBP and DBP were 75.08±9.44 bpm, 112.40±6.54 mmHg and 73.42±2.82 mmHg respectively before the exercise. After 12-weeks of exercise, mean HR, SBP and DBP were reduced to 73.32±7.64 bpm, 109.40±8.12 mmHg and 68.34±3.70 mmHg [Fig.1] respectively. When the post-exercise value of HR, SBP and DBP was compared with pre-exercise value, only reduction in DBP was statistically significant (p<0.0001).

Table 2 shows that the mean values of all time domain parameters (SDNN, RMSSD, NN50 and pNN50) of HRV were increased after exercise training but this increase was not statistically significant.

Table 3 shows that the mean value of LFnu decreases significantly (p=0.0104*) from pre-exercise (53.35±19.07) to post-exercise (43.31±18.76). The HFnu also showed a significant increase (p=0.0231*) from pre-exercise (33.97±13.45) to post-exercise value (38.84±12.62). This significant decrease in LFnu and significant increase in HFnu were shown in Figure 2 and 3 respectively.

Table 1: Effect of IH exercise training on basal cardiovascular parameters

Parameters	Pre-exercise	Post-exercise	‘t’ value	‘p’ value
HR (bpm)	75.08±9.44	73.32±7.64	0.95	0.3432
SBP (mmHg)	112.40±6.54	109.40±8.12	1.89	0.0634
DBP (mmHg)	73.42±2.82	68.34±3.70	7.94	<0.0001*

Data is presented as mean ± SD; * p < 0.05 is statistically significant.
HR = Hear Rate, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure.

Table-2: Effect of IH exercise training on basal time domain measures of HRV

Parameters	Pre-exercise	Post-exercise	‘t’ value	‘p’ value
SDNN (ms)	125.20±22.78	130.00±21.70	1.08	0.2850
RMSSD (ms)	47.12±19.18	49.06±17.34	0.53	0.5937
NN50 (count)	12.06±4.56	13.05±4.20	1.14	0.2587
pNN50 (%)	20.61±8.64	22.08±8.41	0.87	0.3842

Data is presented as mean ± SD; * p < 0.05 is statistically significant.

SDNN = Standard Deviation of Normal-to-Normal intervals, RMSSD = Root Mean Squared Standard Deviation, NN50 = Number of N-N intervals with difference more than 50 milliseconds, pNN50 = Percentage of number of N-N intervals with difference more than 50 milliseconds.

Table-3: Effect of IH exercise training on basal frequency domain measures of HRV

Parameters	Pre-exercise	Post-exercise	‘t’ value	‘p’ value
LF power (%)	79.26±19.01	75.87±16.76	1.14	0.2595
HF power (%)	57.16±21.79	59.13±22.49	0.46	0.6475
LF (n.u.)	53.35±19.07	43.31±18.76	2.66	0.0104*
HF (n.u.)	33.97±13.45	38.84±12.62	2.34	0.0231*
LF: HF ratio (%)	1.38±0.86	1.28±0.70	0.62	0.5349

Data is presented as mean ± SD; * p < 0.05 is statistically significant

LF power = Low Frequency in power percentage, HF power = High Frequency in power percentage, LF (n.u.) = Low Frequency in normalized units, HF (n.u.) = High Frequency in normalized units, LF: HF ratio = Ratio of Low Frequency to High Frequency in power percentage.

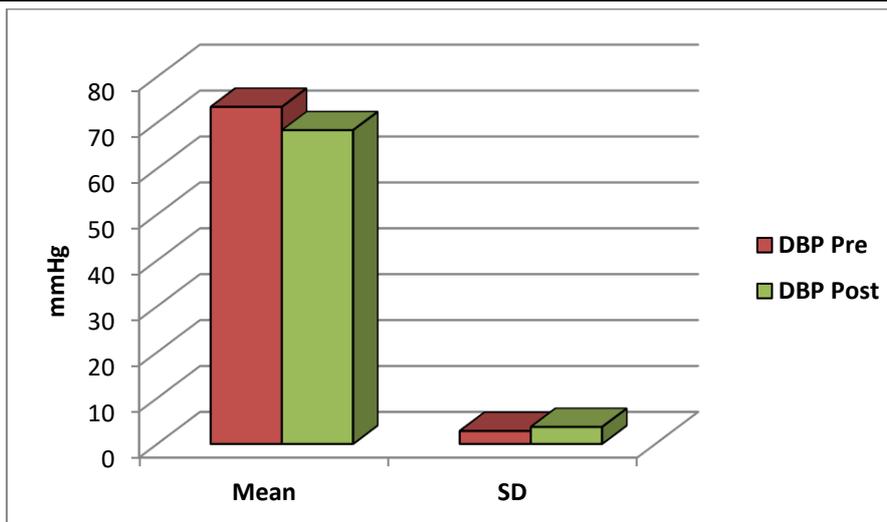


Fig-1: Pre and Post exercise DBP

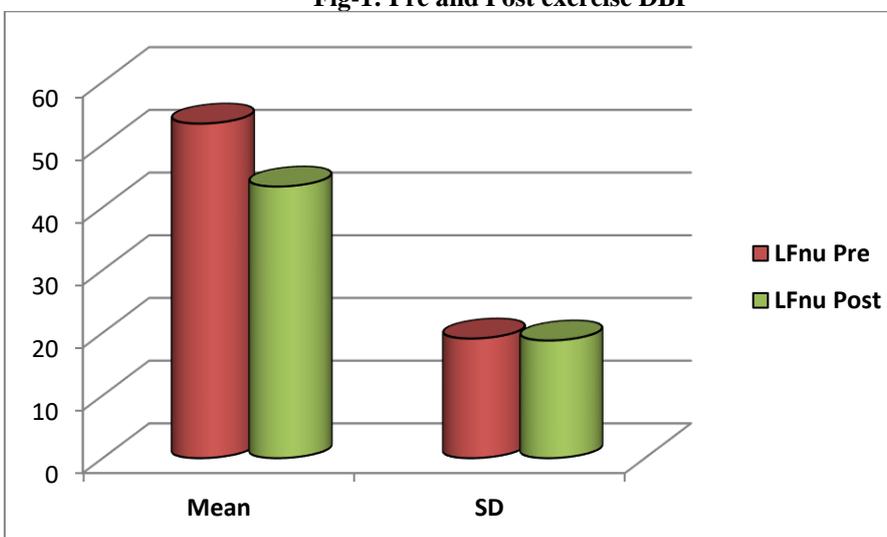


Fig-2: Pre and Post exercise LFnu component of HRV

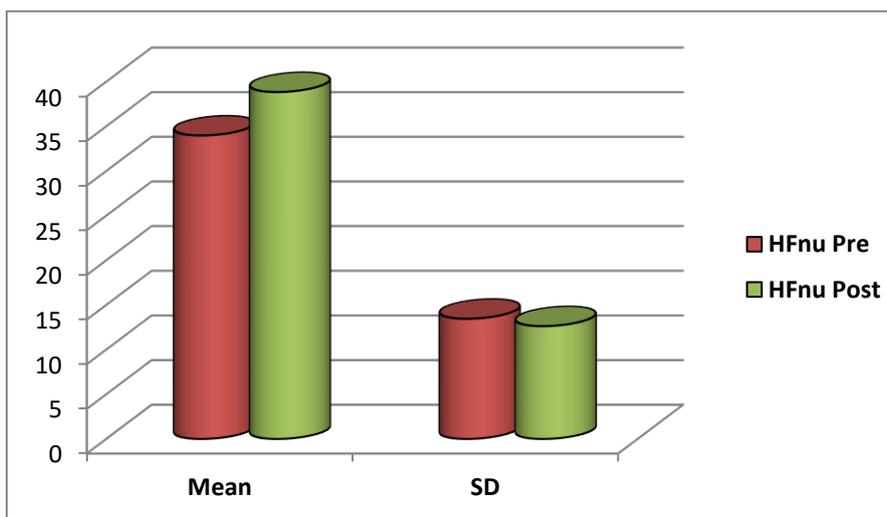


Fig-3: Pre and Post exercise HFnu component of HRV

DISCUSSION

In the present study, the effect of isometric handgrip training on basal cardiovascular parameters

(HR, BP and HRV) in normotensive offspring of hypertensive individuals has been studied.

We found that the subjects showed reduction in HR, SBP and DBP after 12-weeks of isometric exercise training. There was an insignificant reduction in HR and SBP whereas DBP was significantly reduced when compared to their pre-exercise training values.

The effect of 5-weeks of isometric handgrip training resulted in reduction in heart rate and blood pressure during exercise indicating decrease stress on cardiovascular system and showing a positive functional adaptation among prehypertensives young males [13].

The reduction of cardiovascular parameters including heart rate and arterial pressure was an adaptation to isometric handgrip training of 8-weeks in normotensive individuals [14].

The fall in SBP in response to isometric handgrip training found in our study may involve decrease in the heart rate as a result of reduction in sympathetic activity. Similar results have been reported by other investigators [15].

The significant reduction in DBP may be due to adaptations in the vascular system that leads to decrease in systemic vascular resistance. This fall may also be attributed to reduction in plasma norepinephrine levels or decrease in vascular sensitivity to norepinephrine [16], increased antioxidant production, improved endothelium dependent vasodilation and the modulation of autonomic nervous system in the form of reduction of basal sympathetic nerve activity [17].

Recent studies show that a small reduction in DBP has significant health benefits. It has been suggested that a 2 mmHg drop in DBP would lead to 17% decrease in hypertension as well as 6% reduction in coronary heart disease and 15% reduction in stroke-related events. Whereas 5 to 6 mmHg reduction in DBP decreases coronary heart disease and stroke incidents by 16% and 38%, respectively [18]. The 5 mmHg reduction in DBP in our study could have an important impact on these cardiovascular-related illnesses. Furthermore, our results support the concept that isometric handgrip exercise training is an effective modality in the prevention of hypertension.

There are many studies supporting that HRV is affected by isometric exercise training. In the present study, we did not find significant effect on time domain measures of HRV but the trend towards increase in time domain measures such as SDNN, RMSSD, NN50 and pNN50% were observed in the subjects after the completion of 12-weeks of isometric handgrip exercise training. These increased values of time domain measures represent enhanced parasympathetic activity [19].

Among the frequency domain indices, the mean values of LF power and LFnu (significant) was found to be decreased after isometric handgrip exercise training as compared to the values observed before exercise training schedule. These decreased post-exercise training values of LF power and LFnu in the offsprings of hypertensive parents indicate reduction in the sympathetic activity [20].

A higher HF power in percentage as well as higher HF in normalized units represents a rise in parasympathetic tone [21-22]. In the present study, the mean value of HF power was increased but not up to a significant level whereas the mean value of HFnu was increased up to a significant level in the subjects after exercise training. Increased post-exercise handgrip training values of HF power and HFnu shows a positive impact on the parasympathetic tone of cardiac autonomic control.

The decrease in LF: HF ratio was observed after isometric handgrip training indicating probably due to altered sympathovagal balance modulating sinus node activity in response to isometric exercise training which was tilted towards parasympathetic drive. The LF: HF ratio assesses the sympatho-vagal balance [23-24].

These observations revealed that after the completion of isometric handgrip exercise training schedule, the sympathetic activity was decreased and parasympathetic activity was increased in our subjects when compared with their pre-exercise training values. Hence it can be prescribed as a part of lifestyle modification and alternative therapy in improving cardiac autonomic activity that will prevent the risk of developing hypertension in the offsprings of hypertensive parents as they are more prone to early onset of hypertension.

CONCLUSION

The present study revealed that isometric handgrip exercise training can be used as a non-pharmacological intervention in improving cardiac autonomic activity and preventing the chances of development of hypertension in the genetically predisposed individuals.

ACKNOWLEDGMENTS

The authors are thankful to all the participants and Ethical Clearance Committee of Swami Vivekanand Subharti University, Meerut (Uttar Pradesh), India for granting permission of this research work.

REFERENCES

1. Chobanian AV, Bakris GL, Black HR. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment

- of High Blood Pressure. Hypertension. 2003; 42 (6) 1206-52.
2. World Health Organization. The World Health Organization Report 2002: Risks to Health 2002. Geneva: World Health Organization.
3. Kanavos P, Ostergren J, Weber MA. High Blood Pressure and Health Policy: Where we are and where we need to go next. New York, USA: Ruder Finn Inc. 2007.
4. Sharma A, Misra R, Singh K. Comparison of cardiac autonomic activity between offspring of normotensive parents and hypertensive parents. International Journal of Integrative Medical Sciences. 2018; Vol.5 (8):715-20.
5. Soumya R, Maruthy KN, Gupta R. Cardiovascular autonomic responses to whole body isotonic exercise in normotensive healthy young adult males with parental history of hypertension. Indian Journal of Physiology and Pharmacology. 2009; 54 (1): 37-44.
6. McArdle WD, Katch FI, Katch VL. Different muscle actions. Exercise Physiology: Nutrition, Energy and Human Performance. 8th Edition. Philadelphia: Lippincott Williams & Wilkins, a Wolters Kluwer business. 2010; 498-500.
7. Ganong WF. Systemic circulatory changes to exercise. Review of Medical Physiology. 23rd edition, New York: McGraw Hill Company. 2003; 635-42.
8. Barcroft H, Millen JL. The blood flow through muscle during sustained contraction. J Physiol. 1939; 97(1): 17-31.
9. Mark AL, Victor RG, Nerhed C, Wallin BG. Microneurographic studies of the mechanisms of sympathetic nerve responses to static exercise in humans. Circ Res. 1985; 57 (3): 461-9.
10. Seals DR. Influence of force on muscle and skin sympathetic nerve activity during sustained isometric contractions in humans. J physiol. 1993; 462:147-159.
11. Mitchell JH, Payne FC, Saltin B, Schibye B. The role of muscle mass in the cardiovascular response to static contractions. J Physiol. 1980; 309: 45-54.
12. MacDougall JD, Tuxen D, Dale D, Moroz J, Sutton J. Arterial blood pressure response to heavy resistance exercise. J Appl Physiol. 1985; 58: 785- 90.
13. Gandhi S. Effect of isometric hand grip (IHG) exercise training on cardiovascular and echocardiographic parameters among pre-hypertensive young males. International Journal of Physiology. 2016; Vol.4 (1): 166-171.
14. Sandhu JS, Gill HS, Gupta V, Gurmanpreet. Effect of isometric handgrip training on heart rate and arterial pressure in normotensive individuals. Sch. J. App. Med. Sci. 2014; 2 (6A): 2010-2015.
15. Pescatello L, Franklin B, Fagard R, Farquhar W, Kelley GA, Ray CA. American College of Sports Medicine stand. Exercise and hypertension. Med Sci Sports Exerc. 2004; 36 (3): 533-553.
16. McGrown CL, Levy AS, McCartney N, MacDonald MJ. Isometric handgrip training does not improve flow mediated dilation in subjects with normal blood pressure. Clin Sci., 2007; 112 (7): 403-06.
17. Millar PJ, Paashuis A. McCartney N. Isometric handgrip effects on hypertension. Curr. Hypertens. Rev. 2009; 5: 54-69.
18. Cook NR, Chen J, Hebert PR, Taylor JO, Hennekens CH. Implications of small reductions in diastolic blood pressure for primary prevention. Arch Intern Med. 1995; 155 (7): 701-9.
19. Ferreira MJ, Zanesco A. Heart rate variability as important approach for assessment of autonomic modulation. Mini Review. Motriz Rio Claro. 2016; Vol.22 no. 2: 3-8.
20. Rajalakshmi R, Veliath S, Krishnamurthy N and Thenmozhi M. Comparison of cardiovascular parameters and cardiac autonomic activity of obese and normal weight school children in Puducherry. Indian Journal of Physiology and Pharmacology. 2016; 60 (3): 247-254.
21. Bandi HK, Pal P, Pal GK, Balachander J, Jayasettiaseelon E, Sreekanth Y, Sridhar MG, Gaur GS. Effect of yoga therapy on heart rate, blood pressure and cardiac autonomic function in heart failure. Journal of Clinical and Diagnostic Research. 2014; vol.8 (1): 14-6.
22. Report: Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability: Standards of measurements, physiological interpretation and clinical use. European Heart Journal. 1996; 17(3): 354-81.
23. Pal GK and Pal P. Heart rate variability. Textbook of Practical Physiology. 3rd edition. India: Universities Press (India) Private Ltd. Hyderabad. 2010; 291-297.
24. Pagani M, Lombardi F, Guzzetti S, Rimoldi O, Furlan R, Pizzinelli P, Sandrone G, Malfatto G, Dell'Orto S, Piccaluga E, Turiel M, Baselli G, Cerutti S, Malliani A. Power spectral analysis of heart rate and arterial pressure variabilities as a marker of sympatho-vagal interaction in man and conscious dog. Circ Res. 1986; 59(2): 178-93.