

CARDIAC AUTONOMIC ACTIVITY IN OVERWEIGHT AND UNDERWEIGHT YOUNG ADULTS

PUSHPA KRISHNA*, DEEPA RAO AND VISHAL V. NAVEKAR

*Department of Physiology,
Kempegowda Institute of Medical Sciences,
Bangalore – 560 070*

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Abstract : Body mass has been associated with changes in the cardiac autonomic activity. The purpose of this study was to evaluate the cardiac autonomic activity by measuring heart rate variability (HRV) in underweight and overweight young adults. Frequency-domain HRV parameters (TP, LF/HF ratio, LF and HF in absolute and normalized units, where TP – total power, LF – low frequency power and HF = high frequency power) were measured in 124 subjects (mean age 19 ± 1 yr), grouped according to their BMI into underweight [UW, n=12], normal weight [NW, n= 71] and overweight [OW, n=41]. BP (blood pressure) and heart rate were recorded and total body fat was calculated. The groups were similar by age and significantly differed by BMI, body fat (kg), body fat %. OW found to have higher LF in normalised units compared to NW ($P<0.05$). The OW had higher LF, lower HF when expressed in absolute units than NW with no statistical significance. Though not statistically significant, the LF/HF ratio, the index of sympathovagal balance was higher in OW. The UW had lower TP, LF, HF than NW with no statistical significance. The results indicate HRV is decreased in overweight young adults suggesting sympathovagal imbalance. HRV is unaltered in underweight group.

Key words : heart rate variability body mass index young adults

INTRODUCTION

The alteration in the cardiac autonomic nervous system measured in terms of heart rate variability (HRV) is found to be related to body mass (1). There is evidence that sympathetic activity has been enhanced in obesity (2) and an enhanced vagal tone in chronically undernourished subjects (3). Previous studies show complex relationships

between various body mass indices, body fat and autonomic control of the heart. No BMI status was related to LF power but HF (high frequency) power and the LF/HF ratio differed among various body weight groups classified into underweight, normal weight, overweight and obese (4, 5). The effect of BMI on autonomic function has been found to vary with age. Higher BMI in the pediatric population was associated with

*Corresponding author : Dr. Pushpa Krishna, Professor, Department of Physiology, Kempegowda Institute of Medical Sciences, Bangalore – 560070, Ph.: 080-26712791, Fax: 080-26712798, 09343812306; E-mail: pushatte@yahoo.co.in

higher parasympathetic and lower sympathetic activity contrary to HRV responses observed in adults and adolescents (6, 7). The effect of body mass on the cardiac autonomic activity is, well studied in obese individuals, less in underweight and pre-obese population (3, 4, 5). Further, considering the age related changes in sympathovagal balance a particular age group needs to be studied (8). In this study, cardiac autonomic activity was evaluated in age matched overweight and underweight young adults by assessing frequency domain parameters of heart rate variability (HRV).

MATERIALS AND METHODS

The subjects were 124 healthy students from the medical college (63 women and 61 men) in the age group 18-21 years. Subjects with a history of medical illness, on medication, with alcohol consumption were excluded from the study. All subjects gave written consent to the protocol. The study protocol was approved by the Ethics Review Committee of the institution. All subjects underwent an anthropometric assessment. This included measurement of height recorded using a stadiometer, weight to the nearest 100 g. The body mass index (BMI) was calculated as weight divided by height squared (kilograms per meters squared). Body fat (kg) and body fat (%) was calculated using Heitmann and Deurenberg equations respectively (10, 11). Blood pressure was recorded in all subjects using sphygmomanometer in supine position.

The subjects were divided into three groups based on BMI according to WHO guidelines (12). The control normal weight (NW, n=71) subjects had BMI between 18.5

and 25 kg/m². The underweight (UW, n=12) subjects had BMI less than 18.5 kg/m². Overweight (OW, n=41) subjects had BMI between 25-30 kg/m².

Subjects were asked to abstain from tobacco, caffeinated beverages on the test day. All of the ECG recordings were done between 1 pm and 2 pm after a light meal and by the same person. ECG was recorded for each subject by the ECG data acquisition system (Powerlab, AD instruments, Australia) for 5 minutes duration. The subjects were in supine position with eyes closed and breathing normally during the recording.

ECG tracings were subjected to analysis using software (Labchart 6 PRO, AD Instruments Australia) to measure frequency domain of HRV, after exclusion of artefacts automatically. Frequency domain measures obtained were total power (TP), high frequency power (HF), low frequency power (LF), and LF/HF ratio. Components for HRV analysis were expressed both in absolute (ms²) and normalized units (nu). The 0.04-0.15 Hz band of RR power (referred to as LF) reflects predominantly sympathetic activity to the heart, while the 0.15-0.4 Hz band (HF) reflects mainly parasympathetic activity to the heart. In addition LF/HF ratio reflects sympathovagal balance and low HRV reflects reduced parasympathetic activity or increased sympathetic tone. All data acquisition and analyses were carried out in accordance with established standards (13).

Statistical analysis

Statistical analysis was performed using SPSS for Windows (Version 13). Data is

presented as mean±S.D. Correlation between various body mass parameters and heart rate variability indices were computed using linear (Pearson) correlation. Comparisons between the three groups (UW, NW and OW) were carried out using the Kruskal-Wallis test for non-normally distributed data and analysis of variance (two-way ANOVA) was used when data was normally distributed. A natural logarithm transformation was used to normalize distributions of the HRV indices. Post-hoc test using Bonferroni correction was employed, if there was a significant difference between the groups. The null hypothesis was rejected at $P<0.05$.

RESULTS

As shown in Table I, the three groups were similar by age but significantly different by BMI, body fat (kg), body fat %. Table II shows, spectral indices of HRV expressed in both absolute and normalized

units (nu) along with BP, HR values among the three groups. Overweight group had significantly higher LF when expressed in normalised units ($P<0.01$), however OW had higher LF, lower HF when expressed in absolute units than NW with no statistical significance.

Underweight subjects were found to have lower LF and HF expressed in absolute units but higher LFnu compared to NW but the differences were not statistically significant.

Compared to NW group, OW has significantly higher mean systolic and diastolic blood pressure ($P<0.05$). The UW had no difference in BP. Heart rate was not different among the groups.

The association between BMI, body fat (kg) and body fat (percentage) with HRV indices are presented in Table III. Body mass

TABLE I: Characteristics of study groups.

Parameter	UW (n=12)	NW (n=72)	OW (n=40)
Age (years)	18.83±1.40	19.41±1.45	19.63±1.35
BMI (kg/m ²)	17.51±0.95	21.91±1.84	26.97±1.43*
Body fat (kg)	2.64±2.07	11.07±3.56	19.47±3.83*
Body fat (%)	14.55±5.72	20.86±5.26	25±5.57*

TABLE III: Correlation of HRV with body mass parameters.

Body mass parameters	LFnu	HFnu	LF/HF
Body fat (kg)	0.090	-0.140	0.131
Body fat (%)	-0.116	0.007	-0.079
BMI	0.117	-0.141	0.167

TABLE II: Comparison of HRV spectral power between the BMI based study groups.

Parameter	UW (n=12)	NW (n=72)	OW (n=40)
Total Power (ms ²)	1808.10±1225.82	2438.27±1720.02	2120.64±1784.50
LF (ms ²)	448.93±286.79	633.34±622.79	645.62±774.84
HF (ms ²)	618.75±617.93	932.33±830.02	678.71±835.07
LFnu	43.69±12.59	40.35±17.52	47.75±15.76*
HFnu	46.90±12.66	47.99±16.33	41.82±16.01
LF/HF	1.06±0.52	1.09±0.90	1.48±1.07
Heart Rate	86.24±8.70	80.35±9.90	83.17±8.88
SBP (mm Hg)	114.83±5.49	114.65±8.35	123±10.8*
DBP (mm Hg)	74.5±6.88	73.97±6.77	77.64±5.5*

Values are means±SD.

* $P<0.01$ compared with NW group.

TABLE IV: Gender difference in HRV of different BMI groups.

		<i>TP</i>	<i>LF</i>	<i>LFnu</i>	<i>HF</i>	<i>HFnu</i>	<i>LF/HF</i>
UW	Men (n=6)	1724.59 (1124.77)	477.02 (322.92)	49.07 (8.5)	514.48 (473.56)	43.17 (9.93)	1.22 (0.45)
	Women (n=6)	1891.61 (1422.65)	420.84 (272.27)	38.32 (14.38)	723.03 (767.91)	50.64 (14.85)	0.89 (0.57)
NW	Men (n=30)	2844.42 (1777.1)	780.61 (756.49)	42.95 (17.84)	1091.67 (899.09)	47.48 (16.74)	1.17 (0.93)
	Women (n=42)	2148.16 (1637.84)	528.15 (489.59)	38.49 (17.26)	818.52 (767.72)	48.36 (16.21)	1.03 (0.89)
OW	Men (n=24)	2385.29 (2045.05)	769.38 (958.44)	51.80 (18.14)	717.12# (859.69)	39.80# (18.71)	1.81# (1.26)
	Women (n=16)	1723.67 (1259.64)	459.97 (301.99)	41.67* (8.69)	621.08 (820.94)	44.85 (10.42)	0.99* (0.34)

Values are means (SD).

*Compared with men of the same group.

#Compared with NW men.

Index did not show any significant relation to heart rate variability.

Comparison of HRV parameters among men and women of different BMI groups is presented in Table IV. OW women had significantly low LFnu and LF/HF. No significant differences were found in the other BMI groups.

OW men had significantly less HF, HFnu and LF/HF ratio compared to NW men. The differences were not significant on comparing OW women with NW women.

The small sample size of UW men and women (both n=6) did not allow us to compare the data.

DISCUSSION

In the present study, no significant changes were found between the frequency domain parameters of HRV of the subjects with normal BMI and low BMI in spite of

having significantly different calculated body fat mass, fat free mass and percentage body fat. Similarly, underweight population did not have any change in HRV indices as reported by Wu et al (2008) (4). Vaz et al (2003) have shown unaltered sympathovagal balance in underweight people (3). However, significant changes in HRV were found in thin young women with low BMI (14). Ishizawa et al (2008) have shown that anorexia nervosa patients (of mean age 22.9 ± 5.9 years) with low BMI had significantly higher HF in absolute units and significantly lower LF/HF ratio compared with controls indicating reduced increased parasympathetic nervous responsiveness and cardiovascular sympathetic (15). In addition, Cong et al (2004) showed a reduction in LF/HF in Dysorexia nervosa patients with low BMI thus implying an altered sympathovagal balance (16). In the present study also, LF/HF ratio was reduced in underweight group.

Low HRV in underweight population has been linked to nutritional deficiencies (17),

diet (18) and hormonal imbalances (19). In our study sample, the subjects were healthy and low BMI in such persons can be attributed to various factors like, for example, the subjects could be constitutionally thin or perhaps more active than their peers. We have not considered the physical activity of the subjects. However, the differences in the HRV were found to be independent of the physical activity level between the undernourished and normal weight subjects (3). The relatively small sample size of underweight subjects may also have contributed. We have also not assessed their diet.

In this study, overweight young subjects showed significant increase in LF in normalised units though there were no significant changes in HF in absolute as well as normalised units when compared with normal weight group. Increase in LF in normalized units might be because of sympathetic overdrive. Human obesity is associated with marked sympathetic activation and the baroreflex impairment (20). A large population based study has revealed that in the subjects with BMI 25–29.9 kg/m² (obese I), there was no difference in LF, but they had reduced HF, increased LF/HF compared to normal weight subjects (4). Increased values for the body mass index were associated with a shift in sympathovagal balance trending towards sympathetic dominance in young men (21). The overweight girls were found to have increased LF, decreased HF and showed less favourable indices of HRV (22). However, another study by Sztajzel et al (2009) showed no significant difference in LF and HF in absolute units, LF/HF ratio in women with BMI 25–30 kg/m² when compared to those with BMI < 25 kg/m² (5).

Studies have shown association between HRV indices and body fat parameters. The high body fat percentage was associated with low sympathetic modulation of the heart rate in healthy adolescent/young adults implies that body fat percentage determines cardiac sympathovagal balance in healthy subjects (23). In the present study body fat parameters did not show any significant relation to heart rate variability.

Looking at the gender differences in HRV parameters in different BMI groups, LFnu and LF/HF ratio was found to be significantly less in women than men of overweight group only. This decreased sympathetic activity can be attributed to the presence of female sex hormones influencing the autonomic activity. Similar differences have been observed in previous study by Moodithaya S et al (2012) and Ramaeker et al (1998) (24, 25). Also the lower HF and HFnu and LF/HF ratio observed in OW men compared to NW men, indicate enhanced sympathovagal imbalance in OW.

The responses observed in autonomic function vary across the age groups. The recent studies have reported the age related fluctuation in HRV (24, 8). Since this study includes young adults in the particular age group, the effect of BMI on HRV might be different.

In addition, duration of obesity and distribution of fat, seem to be contributing for alteration in HRV. The children with a shorter history of obesity showed a marked sympathovagal imbalance, characterized by a reduced tonic cardiac vagal outflow and sympathetic hyperactivity compared to children with a longer duration of obesity

(2, 9). A study indicates that central fat is associated with less favourable indices of HRV suggesting that distribution of fat might be an important measure to assess the cardiac autonomic functions (22). So influence of these two on HRV also has to be considered.

In the present study both SBP and DBP were significantly higher in overweight group suggesting increased risk of hypertension. Similarly, Schmid et al (2010) have observed a significant positive correlation between body mass index and blood pressure and report young men being overweight have risk of increased blood pressure (21).

Asian Indians have been reported to be at increased risk of diabetes, hypertension and heart diseases (26, 27). In the present study the overweight young adults are having sympathovagal imbalance and might have increased risk for adverse cardiovascular events. Overweight adults are found to have higher prevalence of many chronic diseases with prevalence ratios greater in younger than in older adults (28, 29). Many studies

have linked obesity to cardiovascular risk. Hence, proper preventive measures employed early to control weight can effectively arrest autonomic alterations before it becomes pathological.

Limitations

The small number in UW group limits the study which can be improved by taking comparable sample size. An important aspect while evaluating the relationship between BMI and HRV is physical activity and the type of diet, which we have not addressed in the present study.

Conclusion

The results show that the HRV is decreased in overweight young adults especially men indicating sympathovagal imbalance. No changes were observed in HRV in underweight group. Changes in the autonomic nervous activity begin in the overweight and may become more prominent in the obese thus indicating increased cardiovascular risk.

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