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ORIGINAL ARTICLE

Comparison of Heart Rate Variability among Young Malay Male Adult with Different BMI and Level of Adiposity

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ABSTRACT

INTRODUCTION: Subclinical changes that occur in the heart at an early age may provide valuable information to outline prevention strategies for cardiovascular diseases. Heart rate variability (HRV) reflects regulation of autonomic balance, heart, and vascular tone, which are the determinants of blood pressure. Therefore, this study aimed to determine the difference in heart rate variability (HRV) of Malay male young adult with their BMI and adiposity level. **MATERIALS AND METHODS:** A total of 201 Malay male young adult aged between 19 to 24 years old were screened and their BMI and adiposity level were measured. Three non-invasive tests; Valsalva Manoeuvre, orthostatic response and 30/15 ratio of heart rate were performed. Short term HRV time and frequency domains were recorded. **RESULTS:** Despite few significant differences in HRV parameters of overweight/obese subjects, the result is inconclusive to conclude any reduced variability. However, those with high adiposity regardless of their BMI reported significantly lower mean of R-R SD in time domain and lower mean of LF/HF ratio in frequency domain. The orthostatic reflex results revealed that high adiposity subjects had significantly lower mean of LF and HF. A decrement of -0.28 ms^2 HF/LF during Valsalva manoeuvre, -0.35 LF ms^2 in orthostatic reflex and 0.33 ms^2 in orthostatic reflex per 1% of body fat percentage were observed. **CONCLUSION:** HRV parameters were inversely proportional to the adiposity level which was suggestive of modulation of sympathetic function can occur at an early age.

KEYWORDS: Autonomic regulation, Heart rate variability, Valsalva, Metabolic syndrome

INTRODUCTION

The heart is the centre of cardiovascular system, which is vitally responsible for pumping blood throughout the body. The normal resting heart rhythm is often highly variable rather than monotonously regular. Variability in the heart rhythm known as heart rate variability (HRV), has become a subject of interest in studying the heart function. HRV can be defined as beat-to-beat variation in either heart rate or the duration of the R–R interval, which is also known as the heart period.[1] This beat-to-beat variation is mainly controlled by the autonomic nervous system (ANS) through the simultaneous interplay of sympathetic nervous system (SNS) and parasympathetic nervous system (PSNS) activity at the sino-atrial and the atrioventricular node.[1-2]

Sympathetic stimulation which is often regarded as "fight or flight" response increases the heart rate (HR), contractility and conduction through the

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mediation of adrenoceptors via the release of epinephrine and norepinephrine.[3] Parasympathetic stimulation which is regarded as "rest and digest" response on the other hand, has the opposite effects through mediation of muscarinic receptor. Upon activation of muscarinic receptor, the release of acetylcholine will retard the action potential of SA node which will consequently reduce the heart rate (HR).

Increase in HRV represents the heart's flexibility or positive adaptation to any stress whilst a reduction in HRV is an indicator of health problems due to decreased vagal control of the heart rhythm and reduced β-adrenergic responsiveness.[4-5] According to a global report on non-communicable diseases (NCDs) by World Health Organization (WHO), cardiovascular diseases contributed up to 45% of all NCD deaths and South-East Asian countries have the highest morbidity rate. Malaysia is one of the countries reported to have high mortality and morbidity rates due to NCDs. According to another report by WHO in 2014, Malaysian males aged between 30 and 70 years had significantly higher mortality rates than females. It is important to study the contributing factors to this problem.[6-7]

There are several factors affecting HRV which can be classified into physiological, pathological, environmental, lifestyle and non-modifiable (age and gender) factors. It is vital to understand these factors in order to manage a healthy HRV. Physical activity and body weight play important roles in influencing HRV status because these factors affect ANS function. Those who are physically active are reported to have increased HRV.[8-9]

It has been reported that physical activity may lead to brain stem cardiorespiratory centre remodelling which consequently resulted in cardioprotective reduction of SNS and enhancement of PSNS heart activity outflow.[9] Increased adiposity and body weight are major outcomes of inactivity, therefore these factors may be the indicators that reflect reduced autonomic function. The ANS disequilibrium in obesity may lead to the increased risk of cardiovascular mortality.[10-11] Besides that, elevated adiposity and body weight correlates with a reduction in HRV.[12] Hence, loss of weight may contribute to restoration of ANS function and improvement in HRV.

There is a paucity in literature or data on HRV in Malaysia, particularly young adults. To the best of our knowledge, this is the first report on HRV status of the Malay male young adult associated with adiposity.

MATERIALS AND METHODS

Study design

This cross-sectional study was conducted as part of the Physiological and Physical Fitness of Malaysian Male Youth in Malaysia and the sampling technique adopted was purposive sampling. Subjects were recruited at various universities, community centres and youth clubs around Klang Valley and Negeri Sembilan, Malaysia. The sampling frame includes healthy Malay male aged 18 to 24 years old. The age range was based on the WHO classification of young people (10 – 24 years of age), in this study we include the age of young adults after they completed their secondary education.[13] Those who had history of musculoskeletal injuries, diagnosis of any communicable or non-communicable diseases, congenital disorders, history of drug abuse or growth disorders were excluded from this study. Advertisement with specific inclusion and exclusion criteria was done using flyers and posters at all the identified venues. The recruitment was conducted from July 2016 until July 2017. The study protocol was reviewed and approved by the Ethics Committee of Universiti Sains Islam Malaysia (Ethical number: USIM/REC/0416-3).

Study Population

A total of 213 Malay male young adult volunteered to participate in this study. All subjects were screened using a detailed demographic questionnaire. Their health status were screened based on previous medical records, random blood sugar history and basic physical examination performed by physicians. They were briefed thoroughly on the study and written informed consent was obtained. However, 12 participants were excluded due to either raised of blood pressure or high random blood sugar during the screening.

Body anthropometry and physical activity measurement

Subjects' height (without shoes) were measured using InBody BSM 170/170B Stadiometer (Korea), whilst the weight, fat free mass, fat mass, and fat percentage with light clothing without shoes was determined via InBody 270 Body Impedance Analyser (Korea). Those who obtained BMI of >24.9 kg/m^2 was categorised in the overweight/obese group whilst those who obtained BMI of 18.5 – 24.9 kg/m^2 was categorised in the normal group. Subjects were also categorised based on their adiposity level. Subjects with body fat percentage of 8% - 19% was categorised in the normal group (Group 1) while those with more than 19% body fat categorised as high adiposity group (Group 2).

Heart rate variability (HRV) measurements

Three non-invasive autonomic nervous system function tests (Valsalva Manoeuvre, orthostatic response and 30/15 ratio of heart rate) were performed, prior to which the subjects were requested to rest for 5 minutes. They were allowed two minutes of rest after each sessions. HRV was recorded using CamNtech Actiheart Sensor and Actiheart reader (England). This device utilises the principle of 2 leads electrocardiography to determine the magnitude between each heart beats. There are two important domains in HRV; the time domain and the frequency domain. Parameters for the time domain include maximum R -R time (ms), minimum R-R time(ms), and R-R standard deviation (SD). The frequency domain includes low frequency (LF), high frequency (HF) and LF/HF ratio.[14]

The first test was the Valsalva Manoeuvre, each subjects was trained and instructed to maintain pressure of 40mmHg for 10 seconds by blowing through a mouthpiece attached to an aneroid manometer. Recording of the HRV was done throughout the manoeuvre until 30 seconds after the release of pressure. The Valsalva ratio (VR) was calculated based on the longest R-R interval after Valsalva manoeuvre: shortest R-R interval during Valsalva manoeuvre.

The main parameter for orthostatic reflex test is postural mean blood pressure index (PMBPI). Blood pressures (BP) were recorded using OMRON HEM-7120 Automatic Blood Pressure Monitor (Japan) in supine position and while standing up after 15 minutes of rest. The whole procedure was repeated 3 times. The result of PMBPI ([quick standing mean blood pressure-recumbent mean blood pressure]/ quick standing mean blood pressure X 100) was categorised into three, namely, good (positive results), moderate (0.05% to -18.0%) and poor (<-18.0%).[15]

The 30/15 ratio of HRV was performed concurrently with the orthostatic reflex test. The 30/15 ratio was calculated as the ratio of the R-R interval at 30 second after standing to the R-R interval at 15 seconds after standing. The test was repeated twice and the highest ratio obtained was taken as the 30/15 test value.[16]

Data analysis

Normality of the data was obtained using the Kolmogrov-Smirnov test. The differences in all variables were examined using independent *t*-test. Linear regression was used to determine the relationship between subjects' fat percentage, BMI and physical activities with the HRV parameters and PMBPI. The significance was set at p <0.05. The data were analysed using the IBM Statistical Package for the Social Sciences version 24.0 software (USA).

RESULTS

A total of 201 subjects were eligible for this study. The overall mean age of the subjects was 20.9 years (SD=2.9 years), with a range of 18–24 years. Their mean BMI was 22.7$\pm$4.3 kg/m^2. Our analysis revealed that there were significant differences (p < 0.05) between the overweight/ obese subjects (BMI>24.9) and the normal weight subjects (BMI: 18.5–24.9) in a few variables. Overweight/ obese subjects showed a significantly lower mean in LF/HF during Valsalva manoeuvre and a lower means in LF and HF during orthostatic reflex. Lower R-R SD and VR mean values were also recorded in overweight/obese subjects, even though the results were not statistically significant.

Further analysis based on adiposity levels showed that during Valsalva Manoeuvre, Group 2 subjects (adiposity >19%) have significantly lower mean of R-R SD in time domain and lower mean of LF/HF ratio in frequency domain. Their orthostatic reflex result further revealed that Group 2 subjects have significantly lower mean of LF and HF. There were also significant differences in the BMI between the two groups (Table I). Based on these findings, BMI was controlled for the subsequent linear regression analysis. Linear regression indicated that there was significant adiposity-related decrease in subjects' HF/LF during Valsalva manoeuvre and also the HF and LF in orthostatic reflex. Overall decrement of -0.28 ms^2 HF/LF during Valsalva manoeuvre, -0.35 LF ms^2 in orthostatic reflex and 0.33 ms^2 in orthostatic reflex per 1% of body fat percentage were observed.

Table I: General characteristics of the study population

Variable	Group 1 (Normal)	Group 2 (High adiposity)	Overall	*p*
	(n = 93)	(n = 108)	(n = 201)	
Age(years)	21.4 (1.5)	20.3 (2.6)	20.9 (2.9)	0.86
Height (cm)	167.9 (4.2)	167.9 (5.5)	167.7 (6.0)	0.94
Weight (kg)	67.3 (5.6)	81.1 (10.2)	67.7 (15.5)	0.59
BMI (kg/m2)	22.2 (3.4)	25.7 (5.2)	22.7 (4.3)	0.73
Body fat (%)	18.4 (7.2)	21.7 (8.6)	19.8 (8.0)	0.06
Valsalva manouevre				
R-R max (s)	1.0 (0.1)	0.9 (0.2)	0.9 (0.1)	0.93
R-R min (s)	0.7 (0.1)	0.6 (0.1)	0.7 (0.1)	0.59
VR	1.5 (0.3)	1.4 (0.3)	1.3 (0.5)	0.88
R-R SD (ms)	82.4 (70.2)	68.0 (30.7)	79.5 (45.9)	0.46
HF (ln)	5.6 (1.6)	5.5 (1.5)	5.6 (1.6)	0.35
LF (ln)	7.3 (1.1)	7.0 (1.1)	7.2 (1.1)	0.11
LF/HF*	9.7 (10.4)	6.7 (5.9)	8.4 (9.0)	0.03*
Orthostatic Reflex				
PMBPI (%)	7.9 (6.2)	7.8 (5.4)	8.0 (6.0)	0.98
R-R max (s)	1.1 (0.2)	1.2 (0.3)	1.1 (0.3)	0.41
R-R min (s)	0.6 (0.1)	0.6 (0.1)	0.6 (0.1)	0.14
R-R SD (ms)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.11
HF (ln)*	6.6 (1.6)	6.5 (1.5)	6.5 (1.3)	0.02*
LF (ln)*	7.3 (1.1)	7.0 (1.1)	7.3(1.0)	0.01*
LF/HF*	2.9 (1.7)	2.5 (1.7)	2.6 (1.8)	0.06
30/15 test				
30/15 ratio	2.0 (0.4)	2.2 (1.0)	2.1 (1.6)	>0.15

BMI: body mass index; VR: Valsalva ratio; R-R SD: R to R standard deviation; HF: high frequency; LF: low frequency; PMBPI: Postural mean blood pressure index.

*significant difference ($p < 0.05$)

The values of all variables are expressed in mean (standard deviation)

DISCUSSION

Malaysia is experiencing rapid phase of urbanization in recent decades, thus leading towards increased intake of energy, fats and sugars.[17] The recent concern being highlighted with the increased of intake is the rise of metabolic syndrome and non-communicable diseases especially cardiovascular diseases and diabetes in the near future.[18] Data from Mohamud *et al.* (2011) indicates that prevalence of overweight and obesity among Malaysian adults are 33.6% and 19.5% respectively.[19] Similar trend is reflected among Malaysian adolescents, based on few independent studies, the prevalence of overweight and obesity ranges from 5% to 26%.[20] There are various factors that may have lead towards the current obesity epidemic in Malaysia and inactivity has been emphasised as the main contributor towards weight gain among young Malaysian adults.[21] A combination of low physical activity and weight gain is worrying as both conditions are associated with impaired baroreflex function and low HRV. Subsequently, low HRV is the strong risk factor for heart diseases.

The baroreflex tests that were applied in this study demonstrate functions of either sympathetic or parasympathetic autonomic nervous system in the subjects. Any abnormal results or reduced HRV reflect autonomic dysfunction or imbalance.[22] Orthostatic tests in this study found the LF and HF to be significantly lower in overweight/obese subjects and high adiposity subjects when compared to normal weight subjects. The distinct results found in our young adults may suggest that high adiposity and body weight modulate the sympathetic function at early age. These findings are consistent with a few other published studies among young adult.[23] Previous study in Turkey compares the HRV function between obese and normal weight children found no significant differences for all HRV parameters in orthostatic test, hence suggesting intact sympathetic function in children.[16] On the contrary, 2011 Penn State Children Cohort study found that cardiac autonomic modulation occurs in obese children. It is alarming that impairment of autonomic nervous system can occur at a very early age due to body weight. Furthermore, the modulation predisposes young generations to early cardiovascular diseases especially ischaemic heart disease.[24]

Valsalva manoeuvre test is used in this study to determine the vasovagal function based on short term HRV. The mean of VR among the subjects in this study was found to be lower from other studies involving young adult male.[25] Compelling significant result of lower HRV indicated by the spectral analysis of HF and LF in this study pointing to significant difference of parasympathetic function is associated with body weight and adiposity. Despite some debate over the branch of autonomic nervous system that affects measures of spectral analysis, the consensus is that lower values of HF indicates lower parasympathetic influence and further associated with prospective cardiovascular events.[26] Low HRV reflected by SDNN, LF and LF/HF ratio has strong associations with arrhythmia, congestive heart failure mortality, and ischaemic and non-ischaemic cardiomyopathies.[27] Hypothetically, adiposity is closely related with autonomic function as the ANS innervates fat depots that further influence ANS production of catecholamine. Adipocytokines that are secreted by fat cells are believed to be the main contributor to autonomic dysfunction.[28] Windham *et al.* (2012) found that as the adiposity increases, HRV decreases.[29] Consistent with the animal study, linear regression analysis in this study also found that adiposity in young adults has adverse effects on HF, LF and HF/LF ratio suggesting reduce autonomic response with every increase of adiposity.

One of the limitations in this study includes the relatively small sample in a cross-sectional analysis. However, this study is part of an ongoing study that will further analyse the robust effect of different types of activities on adiposity and HRV of healthy young adults. Furthermore, HRV parameter in this study is exclusively from short term HRV tests that lacks information of autonomic activity influenced by circadian rhythm.[30] Participants for this study were all healthy young adults, thus providing insights on reversible stage of deleterious effect of adiposity to the heart. Nonetheless, this subclinical cardiovascular problem provides an opportunity for early intervention.

CONCLUSION

In summary, there is an inverse relationship between body weight and adiposity of healthy young adults with heart rate variability. Decreased HRV in association to adiposity can develop at early age suggesting that recent high prevalence of obesity have serious impact on early cardiovascular events in our population. However, realising the fact that autonomic regulation of heart rate is the result of a complex mechanism, short-term HRV measures in this study only partially captured cardiac autonomic function.[31] Further long-term HRV investigations are needed to identify other factors that contributes to the sympathetic overactivity and parasympathetic withdrawal in healthy young adults. Finally, salubrious intervention must be suggested to reverse autonomic imbalance that occurs due to adiposity.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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CONTRIBUTORSHIP STATEMENT

All authors have substantial contributions to the conception or design of the work, or the acquisition, analysis or interpretation of data, drafting and revising the work for intellectual content, final approval of version published. Authors are also involved in drafting the work or revising it critically for important intellectual content. Thus, the version sent for publication received final approval from all authors. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy, integrity of the work are appropriately investigated and resolved.

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