

Original article

Effects of general obesity on heart rate variability in Thai people with physical inactivity

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Background: Obesity is an important risk factor of cardiovascular diseases. Heart rate variability (HRV), and maximum oxygen consumption (VO_2 max) are parameters of cardiorespiratory function for determining aerobic capacity. However, the studies that investigated the effects of obesity on HRV, pulmonary function and VO_2 max in male participants aged 40 and 50 years, have been limited.

Objectives: This study aimed to compare HRV, pulmonary function and VO_2 max in male participants with normal body mass index (BMI) (18.5 – 22.9 kg/m², n = 10), and Class I obesity (25 - 29.9 kg/m², n = 10) and also to use HRV to assess cardiopulmonary function in obese subjects.

Methods: In all, there were twenty healthy subjects, aged 40 - 50 years. Each subject was measured for their body composition, heart rate variability, pulmonary function and VO_2 max by cycle ergometer. The data were compared for significant differences between groups by using unpaired *t*-tests.

Results: The time domain parameters of HRV in the obese group were lower, low frequency and the ratio of low and high frequency (LF/HF ratio) were also higher when compared with participants with normal BMI. Pulmonary function and maximum oxygen consumption were not significantly different between the groups ($P > 0.05$).

Conclusion: Autonomic balance was diminished in obese participants. Therefore, the assessment of HRV may be applied as a basic screening test before development of cardiovascular diseases.

Keywords: Obesity, heart rate variability, maximum oxygen consumption, pulmonary function, cardiovascular disease.

Currently, Thai society is changing from an agricultural culture to an industrial community. As such, people are living busier and more hurried lives, causing them to lose interest in taking care of personal health causing many problems. ⁽¹⁾ Obesity is a factor that causes people to be at higher risk of diseases and illness, all of which affect quality of life, society, and the economy both within Thailand and around the world. ⁽²⁾

Heart rate variability (HRV) is a parameter that evaluates the balance of the autonomic nervous system (ANS) balance and predicts the mortality and morbidity from cardiovascular diseases. ⁽³⁾ HRV comprises time domain parameters, the standard deviation of NN intervals (SDNN) and the root mean square of successive differences in NN intervals (RMSSD). The frequency domain of HRV consists of low frequency (LF), high frequency (HF), and LF/HF ratio indicating sympathetic and parasympathetic tone balance. ⁽³⁾ The research of Chintala and others which studied effects of being overweight showed that a depressed HRV value was associated with being overweight. ⁽⁴⁾ Additionally, visceral fat had a positive correlation with autonomic imbalance indicated by LF and LF/HF ratio. ⁽⁵⁾

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VO₂ max is the ability of the cardiopulmonary system while doing daily physical activities.⁽⁶⁾ Shanzia and others' findings about the effect of being overweight, and research done by Crump and others in obese participants found that VO₂ max was lower compared to normal BMI.^(7,8) Obesity decreased the pulmonary function, leading to increased work of breathing and a need to exert more energy. As a result, obese people are likely to be more exhausted while performing daily physical activities.⁽⁹⁾

Even though there has been a number of studies about HRV, pulmonary function and VO₂ max in obese volunteers, the effects of overall obesity in middle-aged people in Thailand according to the Asian Pacific BMI criteria are still limited. In middle aged males, their metabolisms decrease due to chemical and hormonal changes, leading to an increased risk of being overweight or obese;⁽¹⁰⁾ this largely results from improper health activity rather than from natural process of bodily change.⁽¹¹⁾ Improper food consumption and sedentary lifestyles are important factors that cause people to be at risk of being overweight or obese.^(12, 13)

The purpose of this study was to investigate the effects of overall sedentary obesity on HRV, pulmonary function, and VO₂ max and also aimed to use ANS by measuring HRV in male volunteers of age 40 - 50 years who were obese or of normal weight.

Data collection procedures

Participants

All participants were informed about the aims, and consequences of this study and that they were free to make any decision to participate in this study according to the Declaration of Helsinki. It was approved by the Naresuan University Institutional Review Board (IRB). An observational study in male subjects aged 40 - 50 years was done to the recruited 20 subjects calculated from Chintala KK, *et al.*⁽⁴⁾ Inclusion criteria were: nonsmoking male participants aged 40 - 50 years with normal BMI (18.5 - 22.9 kg/m²)⁽¹⁴⁾, Obese BMI (25 - 29.9 kg/m²)⁽¹⁴⁾ and also had a level of healthy (20.5 - 27.4%, n = 10) and slightly high and higher (26.5 - 34.3%, , n = 10)⁽¹⁵⁾ skinfold thickness. All subjects did moderate or vigorous intensities of exercise of less than 30 minutes for 5 days per week or 25 minutes 3 days per week.⁽¹⁶⁾ Informed consents were obtained from all subjects who could read and write Thai well before recruitment.

People with underlying cardiovascular, pulmonary

and neurological diseases were excluded. People who had alcoholic beverages, caffeine or central nervous system (CNS) stimulation drugs within 48 hours and those had a musculoskeletal disease were also excluded.⁽¹⁷⁾

Measurements of body composition

The volunteers refrained from drinking alcoholic beverages, caffeine or CNS stimulation for at least 48 hours, and abstained from exercise for at least 24 hours, had no food nor water for at least 4 hours, and abstained from diuretics for at least 7 days and also emptied their bladders for at least 30 minutes before the test.⁽¹⁸⁾ After resting, all subjects, heart rate (HR) and blood pressure (BP) were recorded by cuff blood pressure were recorded (Omron HEM-7130, Omron Corporation, Japan) in a sitting position. The skinfold thicknesses were measured by a skinfold caliper (Jama medical, model 5028, USA) with the intraclass correlation coefficient (ICC) value of 0.89 following as % BF formula = 0.39287 (sum of 3SKF) - 0.0105 (sum of 3SKF) 2 + 0.15772 (age) - 5.18845⁽¹⁵⁾

Body composition was measured by bioelectrical impedance analysis (BIA) (Omron HBF 375, Omron Corporation, Japan) with the intraclass correlation coefficient (ICC) 0.94 in a temperature controlled room. All subjects were requested to clean their hands and feet before standing on the measuring unit with their arms raised and elbows extended straight until the device showed the results.⁽¹⁹⁾

Pulmonary function test

All subjects followed the instructions and received an explanation and demonstration according to the standards of the American Thoracic Society (ATS) and the European Respiratory Society (ERS) criteria.⁽²⁰⁾ The normal values of lung function, forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) and FEV1/ FVC ratio are more than 80% and >75% of the predictions, respectively. Pulmonary function tests were performed through the mouthpiece and the device (Model ST90, Fukuda, Sangyo Co., Ltd. Japan) three times and brought the greatest value for interpretations.⁽²⁰⁾

Maximum oxygen consumption test

The researchers calculated VO₂ max by cycle ergometer (*Monark*, Ergomedic 828 E, Sweden) following the submaximal Astrand-Ryhming test protocol, with a rhythm of 50 repetitions per

minutes (RPM). Sedentary male subjects were initially tested at 1 Kilo Pond intensity (300 - 450 kpm. min⁻¹) to maintain HR between 120 - 170 beats/minutes. ⁽²¹⁾ HR for each stage was recorded throughout the test for six minutes. Constant HR at the fifth-sixth minutes was determined to correct VO₂ max. VO₂ max was calculated from their age factor and body weight to determine absolute (L/min) and relative VO₂ max (mL/kg/min), respectively. ⁽²¹⁾

Heart rate variability analysis

All subjects were instructed to breathe normally in a supine position for at least 20 minutes and before their R-R interval from electrocardiogram was measured using Power Lab and lab Chart V.8 (AD Instrument, Sydney, Australia) by recording electrode on the right arm (RA) and another on the left leg (LL) (lead II ECG). ⁽²²⁾ The ECG activity was recorded continually with a 200-Hz sampling frequency. ⁽⁴⁾ The R-R interval was measured and each average R-R interval was considered for the measurement after correction for artifacts and entropic beats. ⁽²³⁾ Time domain analysis can be analyzed by calculation of indices based on R-R intervals. ⁽²³⁾ Frequency domain calculations by spectral analysis of an array of R-R intervals followed the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, LF and HF were ranged from 0.04 to 0.15 and 0.15 to 0.40 Hertz (Hz), respectively. ⁽²²⁾

Statistical data analysis

Data were expressed as mean values ± standard deviation (SD). The normal distribution of data was tested using Shapiro–Wilk tests. Unpaired *t*-tests

were used to compare the differences between the two groups. *P* < 0.05 was considered to be statistically significant.

Results

The general characteristics of the participants

The results of the study found that the age and height of all subjects were not significantly different between the two groups (*P* > 0.05). However, body weight, BMI and subcutaneous fat thickness were significantly different between the two groups. The mean BMI and the thickness of subcutaneous fat of the subjects with normal BMI were 21.83 ± 1.12 kg/m² and 23.85 ± 3.68 percentage. The body mass index and the thickness of subcutaneous fat in the obesity group were 27.53 ± 1.61 kg/m² and 30.79 ± 2.11 percentage (Table 1).

There were significantly different body fat masses between the groups. The body fat percentages of participants with normal and obese BMI were 17.68 ± 4.37 and 27.07 ± 3.26 percentage, respectively. There was no significant difference of muscle mass and visceral fat in both groups (*P* > 0.05). Heart rate, systolic and diastolic blood pressure showed no significant differences (*P* > 0.05) (Table 2).

Comparison of pulmonary function and maximum oxygen consumption

There was no significant difference of pulmonary function and VO₂ max between the normal BMI and obesity groups (*P* > 0.05). The VO₂ max in normal BMI and obesity groups were 29.33 ± 3.29 and 26.41 ± 4.06 mL/kg/min, respectively, as shown in Table 3.

Table 1. General characteristics of the participants.

Parameters	Normal BMI	Obese BMI	<i>P</i> - value
Age (year)	44.70±4.85	46.40±5.10	0.286
Height (Centimeter)	167.30 ± 4.03	166.40 ± 4.79	0.511
Weight (Kilogram)	62.16±4.76	76.18±4.62	0.022
BMI (kg/m ²) (%Predict)	21.83±1.12	27.53±1.61	0.031
Skinfold thickness (%)	23.85±3.68	30.79±2.11	0.038
HR (BPM)	70.26±8.06	68.16±11.71	0.835
SBP (mmHg)	105.90 ± 7.77	110.80 ± 8.53	0.630
DBP (mmHg)	73.60±6.31	75.30±4.92	0.280

BMI = Body mass index, HR = Heart rate, BPM = Beat per minute, SBP = Systolic blood pressure, DBP = Diastolic blood pressure

Table 2. Bioelectrical body composition analysis.

Parameters	Normal BMI	Obese BMI	P - value
TBF (%)	17.68±4.37	27.07±3.26	0.038
VF (%)	4.25±1.75	6.71±2.81	0.897
FFM (%)	29.49±4.22	26.30±3.15	0.524

BMI = Body mass index, TBF = Total body fat, VF = Visceral fat body, FFM = Fat free mass

Table 3. Pulmonary function and maximum oxygen consumption.

Parameters	Normal BMI	Obese BMI	P - value
FEV1 (%Predict)	85.20±4.58	84.01±4.07	0.627
FVC (%Predict)	95.40±8.81	97.50±7.94	0.512
FEV1/FVC (%)	83.73±6.38	82.07±5.48	0.455
VO ₂ max (ml/kg/min)	29.33±3.29	26.41±4.06	0.304

BMI = Body mass index, FEV1 = Forced expiratory volume in one second, FVC = Forced vital capacity, VO₂ max = Maximum oxygen consumption,

Comparison of heart rate variability

Analysis of time domain parameters, SDNN and RMSSD of obese subjects at 33.48 ± 10.18 and 26.18 ± 11.52 milliseconds were significantly different, compared to volunteers with normal BMI at 72.42 ± 12.18 and 64.38 ± 9.85 milliseconds.

The frequency domain parameters, the LF and LF/HF ratio in both groups was different. The subjects with normal BMI had an LF and LF/HF values of 49.69 ± 13.38 nu and 0.95 ± 0.17 , respectively. Obese volunteers had LF and LF/HF values of 76.02 ± 8.56 nu and 2.05 ± 0.75 , respectively. There was no significant difference of HF nu between the two groups (Table 4)

Discussion

In the present study, obese male subjects were found to have a decreased HRV, with both SDNN

and RMSSD parameters decreased as well as increased LF and LF/HF ratio, associated with increasing sympathetic activity, or autonomic imbalance.⁽²⁴⁾ There was no significant difference of pulmonary function and VO₂ max between groups, but VO₂ max was found to be decreased in obese participants.

Autonomic balance has an important role in regulating the cardiovascular function.⁽³⁾ Obese subjects with higher fat mass in our study had a reduced SDNN and RMSSD as well as increased LF and LF/HF ratio, this suggested that body composition imbalance, increase of BMI and fat mass cause an autonomic dysfunction.⁽⁵⁾ Obesity can lead to increased oxidative stress and inflammatory cytokines, associated with an increase in sympathetic activity as indicated by increased LF and LF/HF ratio which are factors of autonomic dysfunction.⁽²⁵⁾

Table 4. Heart rate variability analysis.

Parameters	Normal BMI	Obese BMI	P - value
MeanRR (ms)	783.78±145.57	494.30±129.78	0.202
SDNN (ms)	72.42±12.18	33.48±10.18	0.027
RMSSD (ms)	64.38±9.85	26.18±11.52	0.031
LF (n.u.)	49.69±13.38	76.02±8.56	0.038
HF (n.u.)	60.38±10.41	45.56±11.85	0.187
LF/HF	0.95±0.17	2.05±0.75	0.024

BMI = Body mass index, Mean RR = Mean R to R interval, SDNN = Standard deviation of N to N interval, RMSSD = Root mean square of the successive differences, LF = Low frequency, HF = High frequency, ms = Millisecond

The cardiopulmonary system is influenced by the ANS and helps to accomplish daily routines efficiently, air that enters the lungs is transferred to disperse energy by the circulatory system for performing daily physical activity. ⁽²⁶⁾ Previous studies showed that morbid obesity (indicated by a BMI greater than 30 kilograms per square meter) caused an increase of body fat percentage, especially in visceral body fat, and can lead to diminished chest and diaphragmatic movement and oxygen uptake ^(9, 27), suggesting that muscle mass and visceral fat mass have a correlation with pulmonary function and VO_2 max. ^(27, 28)

American College of Sports Medicine (ACSM) guidelines recommend a minimum of 30 minutes of moderately intense aerobic exercise for 5 days per week (150 minutes per week) or 25 minutes of vigorous exercise for 3 days per week (75 minutes per week) to improve cardiovascular endurance. ⁽²⁹⁾ Overall obese middle aged males in our study had a higher body fat percentage all over their body, rather than extra fat limited to a specific region. ⁽⁹⁾ This results in an increase of total body fat, but visceral fat and muscle mass were not significantly different, compared to the subjects with normal BMI. This may have been a factor that caused a statistical difference of pulmonary and VO_2 max. Furthermore, people with poor physical performance had a reduced HRV, and increased risk of cardiovascular diseases. ⁽³⁰⁾ All subjects in our research do less exercise than the ACSM guidelines which suggested that increased BMI and fat mass might affect HRV and cause the decline of aerobic capacity in the future. ⁽⁵⁾

Currently, HRV measurement is a simple and reasonably-priced piece of equipment, such as technological smart watches and phones. HRV can be applied to evaluate health promotion and sports competition planning. ⁽²⁴⁾ The present study can serve as a path to health promotion for obese middle aged men, helping them to recognize their health through controlling BMI and body fat.

Conclusion

In the present study, obese middle aged male had a depressed HRV. Therefore, controlling body composition and fat mass is not only essential to improve the ANS but also decrease the risk of cardiovascular diseases.

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Conflict of interest

The authors, hereby, declare no conflict of interest.

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