Pulmonary and Cardiovascular Autonomic Functions in Overweight and Obese Sedentary Thai Women

สมรรถภาพปอดและการทำงานของระบบประสาทอัตโนมัติของหัวใจในหญิงไทยที่มีน้ำหนักเกินและอ้วน

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ABSTRACT

Overweight and obesity are important risk factors for several diseases. The objective of this study was to investigate pulmonary and cardiac autonomic functions in overweight and obese sedentary Thai women aged between 20-40 years old. Subjects were divided into 2 groups: overweight, BMI 25.0-29.9 kg/m^2 (n=9) and obese, BMI 30.0-39.9 kg/m^2 (n=9). Results of pulmonary functions, both static and dynamic lung volumes revealed no significant differences between the 2 groups. Heart rate variability (HRV) in a supine position both time and frequency domains were analyzed. Obese Thai women showed significant increases in sympathetic (LF) and balance of sympathetic and parasympathetic nervous system (LF/HF ratio) ($p<0.05$), while parasympathetic (HF) significantly decreased ($p<0.01$) compared to overweight group. It is indicated that obese have higher risk of cardiac disease more than overweight sedentary Thai women.

บทคัดย่อ

ภาวะที่มีน้ำหนักเกินและอ้วนเสี่ยงต่อการเป็นโรคเรื้อรังต่างๆ งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาสมรรถภาพปอดและการทำงานของระบบประสาทอัตโนมัติของหัวใจในหญิงไทยที่มีน้ำหนักเกินและอ้วน อายุระหว่าง 20-40 ปี อาสาสมัครแบ่งเป็น 2 กลุ่ม: กลุ่มน้ำหนักเกิน ดัชนีมวลกาย 25.0-29.9 กก./ตร.ม. (9 คน) และกลุ่มอ้วน BMI 30.0-39.9 กก./ตร.ม. (9 คน) ผลการวัดสมรรถภาพปอดพบว่าไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติทั้งปริมาตรสถิตย์ของปอดและปริมาตรพลวัต เมื่อวิเคราะห์ความแปรปรวนของอัตราการเต้นของหัวใจ (heart rate variability) ในท่านอนทั้ง time และ frequency domain พบว่าหญิงไทยอ้วนมีระบบซิมพาเทติก (LF) และสมดุลระหว่างซิมพาเทติกต่อพาราซิมพาเทติก (LF/HF) เพิ่มขึ้น ($p<0.05$) ในขณะที่ระบบพาราซิมพาเทติก (HF) ลดลง ($p<0.01$) เทียบกับกลุ่มน้ำหนักเกิน แสดงว่าหญิงไทยอ้วนมีความเสี่ยงต่อการเกิดความผิดปกติของโรคหัวใจมากกว่าหญิงไทยที่มีน้ำหนักเกิน

Key Words: Pulmonary and cardiac autonomic function, Overweight, Obese

คำสำคัญ: สมรรถภาพปอดและการทำงานของระบบประสาทอัตโนมัติของหัวใจ ภาวะน้ำหนักเกิน ภาวะอ้วน

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Introduction

Sedentary activities, such as sitting, using a computer and watching television, are associated with increasing overweight and obesity (Banks *et al.*, 2011). Previous studies over the last 10 years have indicated that sedentary behaviors are risk factors for several health outcomes and indicators of cardiovascular risk.

Overweight or obesity is defined as excessive accumulation of fat in the body which causes increase in the body weight and is a state of excess body weight which determined by calculation of the body mass index (BMI) (Pal *et al.*, 2013). The World Health Organization and National Institutes of Health recommend the following definitions of overweight and obesity: BMI are 25.0-29.9 kg/m^2 as overweight, and ≥30.0 kg/m^2 as obese (Flegal *et al.*, 2005; Haslam and James, 2005). Obesity and weight gain are imposing a growing threat to world health, as in many countries 20–30% of adults are categorized as clinically obese, and their number is still increasing (WHO, 1999). It has become a major health problem due to its increasing prevalence and associated morbidity and mortality (Seidell *et al.*, 1996). Overweight or obesity is an important determinant of health leading to adverse metabolic changes and associated with many cardiac complications with increased mortality risks such as coronary heart disease, heart failure, and arrhythmias. It may affect the heart through its influence on known risk factors such as dyslipidemia and hypertension (Despres *et al.*, 2001).

Previous studies found that female obesity has greatly increased and most it is also followed by related diseases like gout, hypertension, diabetes, cardiac problems, sleep apnea, cancer, osteoarthritis, and many other disorders. It was demonstrated that the prevalence of overweight and obesity continuously increases in both men and higher incidence in women (Ogden *et al.*, 2007). It can cause various deleterious effects to respiratory function, such as alterations in respiratory mechanics, decrease in respiratory muscle strength and endurance, decrease in pulmonary gas exchange, lower control of breathing, and limitations in pulmonary function tests and exercise capacity (Faintuch *et al.*, 2004; Koenig, 2001; Rasslan *et al.*, 2004). Another important is that both weight and height are surrogate measures of body size and are important predictors for pulmonary function measurements (Chen *et al.*, 1993). Fat subjects tend to have lower lung volumes and less chest wall compliance (Ray *et al.*, 1983). A study recently of Alrefaie (2013) found that HRV indices showed sympathetic hyperactivity in overweight late adolescent females and diminished sympathetic response in matching obese group. Both overweight and obese females showed decreased protective vagal influence on the heart (Alrefaie, 2013). Overweight and obese persons have alterations in many body systems such as musculoskeletal, cardiovascular, endocrine and respiratory systems. The most common pulmonary complications in obese children are asthma, obstructive sleep apnea syndrome (OSAS), restrictive lung disease in obese adolescents and obesity-hypoventilation syndrome (Sulit *et al.*, 2005). Therefore, causes of risk factors in pulmonary and cardiac diseases are comparative studied between overweight and obese sedentary Thai women, aged between 20 to 40 years old in this study.

Objective of the study

This study designed to evaluate and compare pulmonary function and cardiovascular autonomic control in overweight and obese sedentary Thai women aged between 20 to 40 years old.

Methodology

Study design and population

The study was descriptive and analytical research by evaluation the results of pulmonary and cardiac autonomic functions in 18 sedentary Thai women. Nine overweight (BMI 25.0-29.9 kg/m^2) and 9 obese (BMI 30.0-34.9 kg/m^2) sedentary Thai women subjects, aged between 20 to 40 years old were recruited. All subjects were completed a confidential health-screening questionnaire. Subjects with history of cardiovascular (i.e. coronary heart disease, arrhythmia and chronic heart failure), arthritis, neuromuscular, pulmonary, diabetes mellitus, alcohol drinking or smoking and hypertension or other debilitating diseases were not included to this study. Participants ask to assess physical examinations, anthropometry, pulmonary function test and heart rate variability (HRV) at our laboratory unit, department of physiology, faculty of medicine, Khon Kaen University.

Ethical approval

A written informed consent from the participants was obtained before testing. The methods of this study has been reviewed and approved by the Khon Kaen University Ethics Committee for Human Research.

Body mass index (BMI)

Weight and height were measured for each participant, according to the WHO guidelines. Participants were weighted without shoes and with minimal clothing by using a digital scale. Height was measured standing with feet together and arms relaxed at the sides. The BMI was calculated as weight (kg) divided by height (m^2).

Waist and hip circumferences (cm)

Waist circumference (WC) was measured at the narrowest part of the torso and hip circumference (HC) were measured around the buttocks at the level of maximal extension in a free-standing position. Waist and hip circumferences were used to calculate waist to hip ratio (waist: hip ratio, WHR)

Pulmonary function test

The evaluation of pulmonary function was performed by calibrated Vitalograph Spirotrac IIS machine in a standing position. The directly evaluated parameters were lung volumes, capacities, Forced Vital Capacity (FVC) performed in this order at least three times each, according to the standards of the American Thoracic Society (ATS) and the European Respiratory Society (ERS) (Laszlo, 2006) with volunteers in the sitting position. Results were expressed as absolute values and as percentages of the reference predicted values (Miller *et al.*, 2010). The obtain the following variables: vital capacity (VC), tidal volume (VT), inspiratory reserve volume (IRV), expiratory reserve volume (ERV). The FVC procedure allowed for the determination of the forced expiratory volume in one second (FEV_1) and the FEV_1/FVC ratio. The MVV was expressed in L/min and as percentages of the reference predicted value.

HRV measurement

Participants were prepared for electrode placement to measure RR interval via a 3-lead EKG. After 10 minutes of rest in the supine position, EKG was recorded according to the standards of measurements, physiological interpretation, and clinical use guidelines for assessment of HRV (Task Force, 1996). The EKG (lead II) was digitally recorded continuously using a desktop computer and acknowledge data collection software (Biopac Systems, USA). Each signal was sampled at 1000 Hz throughout all testing. This program allowed for instantaneous analog to digital conversion of the EKG with recording stored for off-line analysis using a LabChart7 (AD Instruments PowerLab, Australia). In this study, HRV was measured by both frequency domain and time domain analysis. Files were imported to STATA software program version 10 for descriptive analyses of HRV variables based on current recommendations. All resting HRV variables were calculated from the last 5 minutes of resting period.

Time domain analysis measures the changes in heart rate over time or the intervals between successive normal cardiac cycles (Task Force, 1996). Parameters of the time domain are standard deviation of all normal to normal intervals (SDNN), standard deviation of the averages of normal to normal intervals (SDANN) and square root of the mean of the sum of the squares of differences between adjacent normal to normal intervals (RMSSD). SDNN and RMSSD represent total power and parasympathetic activity, respectively. Power spectral density was quantified in total power (the energy in the heart period power spectrum between 0-0.4 Hz); which its physiological significance is obscure; low frequency (LF) (the energy of the spectrum power between 0.04-0.15 Hz), which indicates primarily sympathetic nervous system with minor influence from parasympathetic activity; high frequency (HF) (the energy of the spectrum power between 0.15-0.4 Hz), which reflects solely parasympathetic activity of cardiac function. The LF to HF ratio reflects relative sympathovagal balance. LF and HF were measured in normalized units [n.u. = (LF or HF)/(total power-VLF)]. The representation of LF and HF in n.u. emphasizes the controlled and balanced behavior of the sympathetic (SNS) and parasympathetic (PNS) branches of the autonomic nervous system (ANS). Moreover, normalization tends to minimize the effect on the values of LF and HF components of the changes in total power. Nevertheless, it is recommended that n.u. should be quoted with absolute values of LF and HF power in order to describe in total the distribution of power in spectral components. This study, we, therefore presented LF and HF in n.u. as well as in ms^2.

Statistical Analyses

Data were expressed as mean±SD (median). The STATA 10 Statistical software was used to perform the statistical analysis. Unpaired t-test was used to compare differences in characteristics and all parameters between overweight and obese. Two-sample Wilcoxon rank-sum (Mann-Whitney) test was used when data deviated from normality, p value less than 0.05 was considered to be statistically significant.

Results

Clinical characteristics of overweight and obese sedentary Thai women

Clinical characteristics of overweight and obese sedentary women, aged between 20 to 40 years old are summarized in Table 1. It was observed that weight, BMI, hip circumference (HC) was significantly higher ($p<0.001$), waist circumference (WC), SBP and %total body fat was significantly higher ($p<0.01$). MAP was significantly higher ($p<0.05$) in obese compared to overweight women.

Pulmonary function

The mean dynamic and static lung volumes are shown in Table 2. Results showed that there were no significant differences between overweight and obese Thai women. However, Results of obese women were quite more than overweight women except reduction of ERV in obese women was reduced, e.g. 60% predicted.

Table 1 Clinical characteristics of overweight (n=9) and obese (n=9) sedentary Thai women.

	Overweight (n=9)	**Obese (n=9)**	**P**
Age (years)	29.6±8.2 (29)	29.2±7.6 (30)	NS[b]
Weight (kg)	68.7±4.5 (70.1)	82.0±2.7 (82.3)	<0.001[b]
Height (cm)	159.0±4.6 (158)	158.1±6.3 (159)	NS[b]
BMI (kg/m^2)	27.2±1.5 (26.4)	32.7±1.6 (32.4)	<0.001[b]
WC (cm)	88.2±4.2 (88)	99.0±8.6 (95)	<0.01[b]
HC (cm)	101.8±4.1 (103)	113.1±5.9 (111)	<0.001[b]
WHR	0.87±0.07 (0.9)	0.87±0.05 (0.9)	NS[a]
SBP (mm Hg)	114.8±11.2 (113)	127.8±6.7 (129)	<0.01[b]
DBP (mm Hg)	72.4±7.9 (74)	79.9±7.8 (80)	NS[b]
MAP (mm Hg)	87±8 (88)	96±6 (95)	<0.05[b]
HR (beat/min)	86±13 (91)	84±7 (84)	NS[b]
% total body fat	36.8±1.7 (36.3)	41.8±1.9 (41.6)	<0.01[a]

BMI, Body mass index; WC, waist circumference; HC, hip circumference; WHR, waist to hip ratio; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; MAP, mean arterial pressure; HR, Heart rate. Values are mean±SD (median). Data were tested by Mann-Whitney test[a] and independent t-test[b]. NS is no significantly difference. A value p less than 0.05, 0.01 are significant, high and highly significantly.

Heart rate variability

Table 3 shows all indices of HRV in both time domain and frequency domain in overweight and obese sedentary Thai women. Results showed that parameters in time domain were not significantly different, but parameters in frequency domain of obese women showed higher sympathetic tone (LF) and ratio of sympathetic tone and parasympathetic tone (LF/HF) by 58% and 34% respectively ($p<0.05$). However, parasympathetic tone (HF) of obese women was significantly lower compared to that of overweight women, e.g. 2.2% ($p<0.01$).

Discussion

In this study, the pulmonary function and heart rate variability were evaluated in overweight and obese sedentary Thai women. This study found that VC, FVC, FEV_1, FEV_1/FVC, VT, IRV, ERV and IC in obese women were not significantly different compared to those of overweight women. ERV was reduced in obese women. This is consistent with the study of Jones and Nzekwu (2006) who reported a reduction in the functional residual capacity (FRC), suggesting that the ERV reduces 5% per unit of an increase in BMI and that, above 30 kg/m^2, it reduces

1% per unit of BMI (Jones and Nzekwu, 2006). The authors suggested that the reduction in ERV can be attributed to the obstruction of small airways and a consequent reduction in gas exchange.

Table 2 Pulmonary function of overweight (n=9) and obese (n=9) sedentary Thai women.

	Overweight (n=9)	**Obese (n=9)**	**P**
VC (L)	2.6±0.6 (2.9)	2.6±0.4 (2.7)	NS[b]
VC (% pred)	89.7±14.7 (95)	90.4±11.0 (91)	NS[b]
FVC (L)	2.7±0.6 (2.5)	2.9±0.5 (3.0)	NS[b]
FVC (% pred)	96.4±15.4 (101)	97.7±12.1 (96)	NS[b]
FEV_1 (L)	2.3±0.6 (2.4)	2.5±0.5 (2.6)	NS[b]
FEV_1 (% pred)	92.6±15.5 (87)	98.6±13.6 (104)	NS[b]
FEV_1/FVC (L)	0.8±0.1 (0.8)	0.9±0.1 (0.9)	NS[b]
FEV_1/FVC (% pred)	95.9±6.3 (97)	100.6±6.2 (100)	NS[b]
VT (L)	1.1±0.4 (1.1)	1.3±0.5 (1.3)	NS[b]
IRV (L)	1.4±0.4 (1.4)	1.4±0.9 (1.3)	NS[b]
ERV (L)	0.9±0.3 (0.9)	0.7±0.3 (0.8)	NS[b]
ERV (% pred)	79.6±29.1 (85)	60.0±20.3 (63)	NS[b]
IC (L)	2.0±0.5 (2.2)	2.2±0.4 (2.1)	NS[b]
IC (% pred)	97.9±17.9 (93)	106.2±18.9 (105)	NS[b]

VC, vital capacity; FVC, forced vital capacity; FEV_1, forced expiratory volume in the first second; TV, tidal volume; IRV, inspiratory reserve volume; ERV, expiratory reserve volume; IC, inspiratory capacity; % predicted value. Values are mean±SD (median). Data were tested by Mann-Whitney test[a] and independent t-test[b]. NS is no significant difference

Ladosky and co-workers (2001) comparing group of obese and non-obese patients, also suggested that the reduction of the ERV may be a consequence of air trapping caused by obesity and leading to a reduction in the MVV (Ladosky *et al.*, 2001). In term of %predicted values, there were no significant differences between both groups. A previous study showed that the IC was higher in obese individuals than in non-obese ones, even when all the other spirometric values were within the normal (Rasslan *et al.*, 2004). These authors suggested that this fact may indicate normal lung compliance and an ability of the respiratory muscles to compensate, though temporarily, for the excess weight on the chest and abdomen.

Table 3 Comparison in heart rate variability (HRV) parameters in overweight (n=9) and obese (n=9) sedentary Thai women on supine position.

	Supine		
	Overweight (n=9)	**Obese (n=9)**	**P**
Time domain			
HR (bpm)	75.95±9.37 (77.24)	78.06±10.94 (77.40)	NS[b]
SDNN (ms)	57.79±22.69 (56.05)	47.23±25.32 (36.84)	NS[a]
RMSSD (ms)	62.96±42.27 (35.74)	53.66±42.42 (44.65)	NS[a]
Frequency domain			
LF (n.u.)	24.63±6.61 (22.96)	39.01±14.99 (34.12)	<0.05[b]
HF (n.u.)	58.72±14.80 (61.72)	43.66±10.96 (37.50)	<0.01[b]
LF/HF	0.44±0.13 (0.41)	0.99±0.56 (0.69)	<0.05[b]

HRV, heart rate variability; SDNN, Standard deviation of all NN intervals; RMSSD, Square root of the mean of the sum of the squares of differences between adjacent NN intervals; low frequency power (LF); high frequency power (HF); LF normalized unit (LF n.u.); HF normalized unit (HF n.u.) ratio. Values are mean±SD (median). Data were tested by Mann-Whitney test[a] and independent t-test[b]. NS is no significant difference. A value p less than 0.05, 0.01 are significant and high significantly.

According to our results, no differences were observed between overweight and obese women for the VC, VT and IC. However, obese women showed a reduction in the ERV, possibly offset by the increase in the IRV, thus keeping the VC unchanged. These findings suggest that obesity causes injury to ventilatory mechanics (reducing the ERV).

LF and LF/HF ratio in obese women were significantly higher whereas HF was significantly lower compared to those of overweight women. Time domain analysis of HRV revealed a significant decrease in RMSSD in overweight and obese late adolescent females compared to their matching lean group (Alrefaie, 2013). The foregoing data showed evidence of decrease parasympathetic activity in overweight and obese groups. In support of this concept, this study showed a significant decrease in the HF power in overweight and obese women. In accord with our finding, lower parasympathetic modulation of HRV was observed in obese women. On the other hand, higher parasympathetic modulation of HRV in obese women was reported specially when there was combination of upper body and visceral obesity (Gao *et al.*, 1996).

Interestingly, analysis of the frequency domain components of the HRV in this study showed a significant increase in LF and LF/HF ratio in obese when compared to overweight women suggesting sympathetic over activity, as higher values of LF/HF ratio previously indicated greater sympathetic modulation of HRV (Task Force, 1996). However, another study observed that there was no difference in sympathetic function between normal and obese individuals (Rossi *et al.*, 1989). As well as, the earlier studies in obese Thai adolescent found that no significant difference between obese and normal-weight adolescents, but had trends for higher LF (n.u.), lower HF (n.u.) and higher LF/HF ratio, although not significantly (Khrisanapant. *et al.*, 2008). Thus, it is importance to promote cardiovascular health which is influenced by physical activity, in adult women regardless of normal pulmonary and cardiac autonomic functions and high significantly.

However, future study should increase number of subjects for representative data of pulmonary and cardiac autonomic functions in Thai women including normal weighted subjects.

Conclusion

Obese sedentary Thai women showed higher risk factor of cardiac disease more than overweight women. While both overweight and obese subjects, aged between 20 to 40 years old showed no risk factor of pulmonary disease. In regard to decrease risk factor of cardiac disease in Thai women, it is important to reduce obesity.

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