นิพนธ์ต้นฉบับ • Original Article

สมรรถภาพปอดและการทำงานของระบบประสาทอัตโนมัติของหัวใจ หลัง 12 สัปดาห์ของการฝึกออกกำลังกายด้วยการเดินเร็วและบิดเอวร่วมกับการเพิ่มน้ำหนักที่แขนในคนไทยวัยผู้ใหญ่ที่มีน้ำหนักเกินหรืออ้วน

ปรัชญา ชุมแวงวาปี[1], ธัญดา สุทธิธรรม[2], อรพิน ผาสุริยวงษ์[2], วิไลวรรณ กฤษณะพันธ์[2]
[1]วิทยาศาสตร์การออกกำลังกายและการกีฬา บัณฑิตวิทยาลัย มหาวิทยาลัยขอนแก่น
[2]ภาควิชาสรีรวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น

Pulmonary and Cardiac Autonomic Functions after 12 Weeks of Brisk Walking with Swaying Hips and Hand Weight Loading Exercise in Overweight or Obese Thai Adults

Pruchya Chumvangvapee[1], Tunda Suttitum[2], Orapin Pasurivong[2], Wilaiwan Khrisanapant[2]
[1]Science Program in Exercise and Sport Science, Graduate School of Khon Kaen University.
[2]Department of Physiology, Faculty of Medicine, Khon Kaen University.

หลักการและวัตถุประสงค์: การออกกำลังกายต่อเนื่องอาจทำให้สมรรถภาพปอด (Pulmonary function, PF) และการทำงานของระบบประสาทอัตโนมัติของหัวใจ (Cardiac autonomic function, CAF) ดีขึ้น วัตถุประสงค์ของการศึกษาครั้งนี้ เพื่อศึกษา PF และ CAF ภายหลัง 12 สัปดาห์ของการฝึกออกกำลังกายด้วยการเดินเร็วและบิดเอวร่วมกับการเพิ่มน้ำหนักที่แขน (Brisk walking with swaying hips and hand weight loading, BWSHL) ในคนไทยวัยผู้ใหญ่ที่มีน้ำหนักเกินหรืออ้วน

วิธีการศึกษา: ประชากรที่นำมาศึกษาเป็นอาสาสมัครคนไทยวัยผู้ใหญ่อายุ 20-35 ปีจำนวน 63 ราย แบ่งออกเป็น 2 กลุ่ม; กลุ่มที่ 1 กลุ่มน้ำหนักเกิน (BMI $\geq$ 25-29.9 กิโลกรัม/เมตร^2) เป็นกลุ่มควบคุม (C) 15 ราย, กลุ่มออกกำลังกาย (E) 16 ราย และกลุ่มที่ 2 กลุ่มอ้วน (BMI $\geq$ 30-39.9 กิโลกรัม/เมตร^2) เป็นกลุ่ม (C) 15 ราย, กลุ่ม (E) 17 ราย ทุกคนได้รับการประเมิน PF และ CAF (Heart rate variability, HRV) ก่อนและหลัง 12 สัปดาห์ การออกกำลังกายด้วย BWSHL (มีน้ำหนักที่แขน 0.9 - 2.26 กิโลกรัม) ให้ออกกำลังกาย 40 นาที/ครั้ง (อบอุ่นร่างกาย 5 นาที, ออกกำลังกายที่ความหนักร้อยละ 60-80 ของอัตราการเต้นหัวใจสูงสุด (Maximum of heart rate; HRmax) 30 นาที และคลายอุ่น 5 นาที) อย่างน้อย 3 วันต่อสัปดาห์จนครบ 12 สัปดาห์ติดต่อกัน

ผลการศึกษา: พบว่า BWSHL ไม่มีผลต่อสมรรถภาพปอด (PF) ระหว่างกลุ่มควบคุม (C) กับกลุ่มออกกำลังกาย (E) แต่มีผลทำให้การทำงานของระบบประสาทอัตโนมัติของหัวใจ (CAF) ในกลุ่มออกกำลังกาย (E) พบว่าอัตราการเต้นของ

Background and Objective: Regular exercise may improve pulmonary function (PF) and cardiac autonomic function (CAF). This study aimed to investigate PF and CAF following 12 weeks of an exercise program involving brisk walking with swaying hips and hand weight loading (BWSHL) in overweight and obese Thai adults.

Methods: Sixty-three Thai adult subjects aged between 20-35 years old were assigned to two groups. Overweight subjects (BMI $\geq$ 25 to 29.9 kg/m^2) were assigned to control group (C) (n=15) and exercise group (E) (n=16). Similarly, obese subjects (BMI $\geq$ 30 to 39.9 kg/m^2) were divided into C group (n=15) and E group (n=17). The PF and CAF (Heart rate variability, HRV) were measured before and after 12 weeks of exercise. The exercise consisting of BWSHL (hand weight load of 0.9 - 2.26 kg) for 40 min/session (5 min warm-up, 30 min exercise of 60 to 80% HRmax, 5 min cool-down) with a hand weight load between 0.9 to 2.26 kg, performed at least 3 days per week for 12 consecutive weeks.

Results: Following BWSHL, there were no significant differences in PF between Groups C and E, but CAF in Group E was significantly reduced in HR, SDNN, LF and LF/HF, while HF and RMSSD increased ($p<0.001$) on supine and tilted 70 degrees positions.

***Corresponding author:** Tunda Suttitum Department of Physiology, Faculty of Medicine, Khon Kaen University.
E-mail: stunda@kku.ac.th

หัวใจ (HR), ค่าส่วนเบี่ยงเบนมาตรฐานของข้อมูล standard deviation of all NN intervals (SDNN), ความถี่ต่ำ low frequency (LF) และ อัตราส่วนของความถี่ต่ำต่อความถี่สูง low - and high-frequency spectra (LF/HF) ลดลง ขณะที่ผลของความถี่สูง (HF) และ ค่าเฉลี่ยกำลังสองของค่าเบี่ยงเบนมาตรฐานของข้อมูล (the square root of mean squares of differences between adjacent NN intervals, RMSSD) เพิ่มขึ้น อย่างมีนัยสำคัญทางสถิติ (p<0.001) ทั้งในท่านอนและท่าเอียง 70 องศา

สรุป: การออกกำลังกายด้วยการเดินเร็วและบิดเอวร่วมกับการเพิ่มน้ำหนักที่แขน (BWSHL) 12 สัปดาห์ มีผลพัฒนาระบบประสาทอัตโนมัติของหัวใจดีขึ้น แต่ไม่พบการเปลี่ยนแปลงในสมรรถภาพปอดในคนไทยวัยผู้ใหญ่ที่มีน้ำหนักเกินหรืออ้วน อายุระหว่าง 20-35 ปี

คำสำคัญ สมรรถภาพปอด การทำงานของระบบประสาทอัตโนมัติของหัวใจ น้ำหนักเกินหรืออ้วน

Conclusions: This study shows that 12 weeks of BWSHL improves CAF but not the PF in overweight and obese Thai adults aged between 20 and 35 years old.

Key words: pulmonary function (PF), cardiac autonomic function (CAF), overweight and obesity

ศรีนครินทร์เวชสาร 2558; 30 (5): 474-481. ♦ Srinagarind Med J 2015; 30 (5): 474-481.

Introduction

Overweight and obesity develop as a consequence of an imbalance between energy intake and energy expenditure due to genetics and environment such as sedentary lifestyle, high fat, and fast foods[1]with the prevalence increasing steadily globally[2]. In Thailand, the prevalence of obesity increased by around 19% from 1997 to 2004[3]. It is well established that obesity is one of major contributors to several diseases including coronary heart disease, stroke, respiratory problems and disability[4]. It can cause development of various respiratory disturbances, such as alterations in respiratory mechanics, decreases in respiratory muscle strength and endurance, pulmonary gas exchange, pulmonary function and exercise capacity[4-7].

Aerobic exercise is physical exercise of relatively low intensity that depends primarily on the aerobic energy-generating process. Prolonged moderate aerobic exercise at 65% maximal oxygen uptake

$\dot{V}O_2max$ leads to contribution of fat approximately 40 to 60% of total energy expenditure depending on how long the exercise is performed. On the other hand, strenuous exercise above 75% $\dot{V}O_2max$ primarily burns glycogen[8]. Hand weight load exercise increases energy expenditure whereas walking with hip swinging may strengthen abdominal muscles as well as decrease waist circumference, and/or fat deposit. Resistance training including strength, endurance, and power, the chest press, shoulder press, pull down, dips, lower- black extension, abdominal crunch/curl-up and leg press, 2-3 days/week for a total of 2 to 4 sets with 8 to 12 repetitions per set with a rest interval of 2 to 3 minutes between sets can improve all components of muscular fitness[9].

The measurement of cardiac autonomic function using heart rate variability (HRV) is a noninvasive method that is now accepted[10]. Exercise can improve HRV and function of autonomic nervous system (ANS). Following 12 weeks of exercise training program (brisk walking), increases in vagal-mediated HRV, and also improvement of respiratory muscle strength, pulmonary function, physical performance and cardiovascular endurance and modification of cardiac autonomic control among sedentary Thais were observed[11]. Several studies found that exercise training increased HRV[12, 13] and excutive performance after aerobic training[13].

Brisk walking is often recommended because it is easy to practice and no devices are needed. So far, there has been no study in regard to examining the effects of brisk walking with swaying hips and hand weight load (BWSHL) exercise on the pulmonary function and the cardiac autonomic control. Therefore, this study aimed to investigate these functions following 12 consecutive weeks of BWSHL in overweight and obese Thais. This study aimed to investigate pulmonary and cardiac autonomic functions after 12 consecutive weeks of an exercise program involving brisk walking with swaying hips and hand weight load exercise in overweight and obese Thai adults.

Materials and Methods

Study design and population

This was an experimental study in humans conducted by evaluating pulmonary and cardiac autonomic functions. Sixty-three subjects were assigned into control group (C) and exercise group (E). Thirty-one overweight (BMI 25.0-29.99 kg/m^2) and thirty-two obese (BMI 30.0-39.99 kg/m^2) Thai subjects, aged between 20 to 35 years old were recruited as volunteer subjects both males and females. All subjects 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 were asked to assess physical examination, anthropometry, pulmonary and cardiac autonomic function test at our Laboratory Unit, Department of Physiology, Faculty of Medicine, Khon Kaen University.

Study protocol

Overweight and obese Thai adults aged between 20 to 35 years with the inclusion criteria voluntarily participated in this study. Overweight (BMI 25.0-29.99 kg/m^2, n=31) participants with no involvement in aerobic exercise were assigned to control group (C, n=15), or exercise group, (E, n=16). Similarly, obese (BMI 30.0-39.99 kg/m^2, n=32) were assigned to either control group (C, n=15), or exercise group (E, n=17). Participants in the E group completed aerobic exercise consisting of brisk walking with swaying hips and hand (BWSHL) with a weight load between 0.9 to 2.26 kg for 40 min/session (5 min warm-up, 30 min exercise of 60 to 80% HR max, 5 min cool-down), at least 3 days/week for 12 consecutive weeks. All parameters were measured before and after 12 weeks of aerobic exercise BWSHL program.

Pulmonary function test

The evaluation of pulmonary function was performed by a calibrated Vitalograph Spirotrac IIS machine in a standing position[14]. The directly evaluated parameters were lung volume, capacity, forced vital capacity (FVC) performed in this order at least three times each, according to the standards of the American Thoracic Society (ATS) with volunteers in the sitting position. Results were expressed as absolute values and as percentages of the reference predicted values[15].

HRV measurement

Participants were prepared for electrode placement to measure RR interval via a 3-lead EKG (Lab Chart 7, AD Instruments, Australia). 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[10]. In this study, HRV was measured by both frequency domain and time domain analysis. Files were imported to STATA software program version 12 for descriptive analyses of HRV variables based on current recommendations. All resting HRV variables were calculated from the last five minutes of resting periods.

Time domain analysis measures the changes in heart rate over time or the intervals between successive normal cardiac cycles[10]. 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 using the following metrics: total power (the energy in the heart period power spectrum between 0-0.4 Hz). Low frequency (LF) (the energy of the spectrum power between 0.04-0.15 Hz) 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) reflects solely parasympathetic activity of cardiac function. The LF to HF ratio reflects 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.

Ethical approval

Written informed consent from each participant was obtained before testing. The methods of this study has been reviewed and approved by the Khon Kaen University Ethics Committee for Human Research (HE561482).

Statistical Analyses

Data were expressed as mean ± SD. The STATA 12 Statistical software was used to perform the statistical analysis. Paired t-test was used to compare differences in characteristics and all parameters between overweight and obese pre-versus post-exercise. Two-sample Wilcoxon rank-sum (Mann- Whitney) test was used when data deviated from normality, and a p value less than 0.05 was considered to be statistically significant.

Results

Anthropometry and Pulmonary function

The data are presented as % predicted (Table 1 and 2). No measurements of anthropometry and pulmonary function in overweight and obese subjects showed significant differences between pre- and post-exercise after 12 weeks in either control or exercise groups.

Heart rate variability (HRV)

Data regarding time and frequency domains assessed during supine and tilt positions in control and exercise groups of overweight and obese subjects are shown in Table 3 and Figure 1, 2. We observed significant differences between control and exercise groups after 12 weeks of BWSHL exercise.

In overweight group, the supine HR decreased 10.90%, which was highly significant ($p<0.001$). In time domain assessment, SDNN also decreased significantly (18.50%, $p<0.001$), and RMSSD increased 48.33% ($p<0.01$). In frequency domain assessment, LF (n.u.) decreased 29.73% ($p<0.001$) and HF (n.u.) increased 39.99% ($p<0.001$). LF/HF ratio decreased significantly (56.44%, $p<0.001$) (Table 3 and Figure 1). Similary, tilt HR increased 4.83% ($p<0.01$), SDNN decreased 27.60% ($p<0.001$) and RMSSD increased 23.62% ($p<0.01$). LF (n.u.) decreased 12.49%, and HF (n.u.) increased 19.13% ($p<0.001$). LF/HF ratio decreased 28.61% ($p<0.001$) (Table 3).

In obese group, the supine HR decreased 6.02%, a highly significant difference ($p<0.01$). RMSSD increased 27.62% ($p<0.01$). In frequency domain assessment, LF (n.u.) decreased 17.96% ($p<0.001$). HF (n.u.) increased 15.39% ($p<0.001$). So, LF/HF ratio decreased to a highly significant degree (40.55%, $p<0.001$) (Table 3 and Figure 2). Moreover, tilt HR increased 5.42% ($p<0.01$), SDNN decreased 23.66% ($p<0.001$), RMSSD increased 44.48% ($p<0.001$), LF (n.u.) decreased 13.29% ($p<0.001$) and HF (n.u.) increased 18.10% ($p<0.001$). LF/HF ratio was decreased 31.89% ($p<0.001$) (Table 3).

Discussion

BWSHL exercise and pulmonary function (PF)

This study has shown no significant difference in pulmonary function after 12 weeks of BWSHL. Similarly, a study by Selvadurai and Hiran found no significant difference in pulmonary function indices after aerobic training program compared to no physical training[16]. Also,

Table 1 Baseline clinical characteristics of overweight and obese subjects

	Overweight group		Obese group	
	Control (n=15)	Exercise (n=16)	Control (n=15)	Exercise (n=17)
Age (years)	29 ± 5	24 ± 4	24 ± 6	25 ± 4
Body weight (kg)	72.0 ± 11.9	74.2 ± 10.3	90.2 ± 13.1	90.8 ± 16.5
Height (cm)	162.3 ± 10.1	165.7 ± 9.0	167.3 ± 12.4	167.2 ± 8.6
BMI (kg/m^2)	27.1 ± 1.5	27.0 ± 1.4	31.5 ± 2.0	32.2 ± 3.1
Total body fat (%)	32.7 ± 4.4	30.5 ± 4.0	40.8 ± 3.6	36.1 ± 3.1
Total body water (%)	48.0 ± 4.0	50.4 ± 7.7	42.5 ± 2.8	45.2 ± 4.9
WC (cm)	88.3 ± 7.7	85.8 ± 6.9	97.0 ± 7.9	99.3 ± 11.4
HC (cm)	104.1 ± 5.7	103.9 ± 4.6	111.2 ± 5.4	112.4 ± 7.7
WHR	0.85 ± 0.06	0.83 ± 0.06	0.82 ± 0.13	0.88 ± 0.05
SBP (mmHg)	122 ± 9	113 ± 8	120 ± 8	120 ± 8v
DBP (mmHg)	78.5 ± 12.2	79.0 ± 10.7	73.3 ± 7.0	78.4 ± 7.6
MAP (mmHg)	92.7± 10.9	90.3 ± 8.9	88.5 ± 5.8	92.3 ± 6.0
HR (beats/min)	79 ± 14	83 ± 8	77 ± 11	79 ± 11

Data are presented as mean ± SD. Body weight, BMI, body mass index, % of total body water, 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.

Table 2 Pulmonary function of overweight and obese assessed during pre- and post- exercise (BWSHL) in control and exercise groups

	Overweight group				Obese group			
	Control (n=15)		Exercise (n=16)		Control (n=15)		Exercise (n=16)	
	pre-test	post-test	pre-test	post-test	pre-test	post-test	pre-test	post-test
VC (L)	2.84 ± 0.96	2.83 ± 0.55	3.00 ± 0.73	3.36 ± 0.82	3.14 ± 0.85	3.14 ± 0.74	3.53 ±0.84	3.50 ± 0.97
VC (%pred)	85.86 ± 19.14	84.53 ± 19.05	92.13 ± 13.86	92.69 ± 14.98	92.35 ± 18.75	91.53 ± 18.55	92.29 ± 12.66	91.59 ± 14.00
FVC (L)	2.94 ± 1.23	2.93 ± 1.05	3.41 ± 0.87	3.42 ± 0.91	3.35 ± 1.14	3.23 ± 1.15	3.80 ± 0.91	3.68 ± 0.96
FVC (%pred)	99.36± 8.73	99.23 ± 8.55	95.75 ± 17.26	95.69 ± 16.02	101.33 ± 9.75	100.14 ± 8.75	100.12 ± 13.58	96.82 ± 13.68
FEV_1 (L)	2.73 ± 0.56	2.73 ± 0.35	2.67 ± 0.88	2.79 ± 0.82	2.94 ± 0.73	2.84 ± 0.73	2.80 ± 0.67	3.03 ± 0.67
FEV_1 (%pred)	90.25 ± 11.23	90.14 ± 11.24	86.44 ± 22.35	88.56 ± 17.61	94.34± 13.45	92.53 ± 13.35	86.35 ± 16.33	93.59 ± 13.18
FEV_1/FVC (L)	0.84± 0.34	0.85 ± 0.26	0.78 ± 0.14	0.81 ± 0.09	0.83 ± 0.15	0.84± 0.15	0.74 ± 0.15	0.82 ± 0.11
FEV_1/FVC (%pred)	90.63 ± 12.06	90.44 ± 12.05	81.74 ± 26.38	92.31 ± 10.82	92.24 ± 13.25	91.33 ± 13.25	54.94 ± 15.84	92.65 ± 9.98

VC, vital capacity; TV, tidal volume; FVC, force vital capacity; FEV_1, force expiratory volume in the first second ; IRV, inspiratory reserve volume; ERV, expiratory reserve volume; IC, inspiratory capacity; %pred, %predicted value. Data are presented as mean ± SD tested by paired and unpaired t-test, Wilcoxon signed-rank test. *** p<0.001 Highly significant difference in pre-versus post-test by paired t-test.

Costa and coworkers found no significant differences between the obese group and the non-obese group as to the age, vital capacity, tidal volume, forced vital capacity, and forced expiratory volume in the first second. However, the obese group presents a greater inspiratory reserve volume, a lower expiratory reserve volume and maximal voluntary ventilation than the non-obese group, respectively [17]. On the contrary, Jones reported a 5% reduction in expiratory reserve volume (ERV) per unit of increase in BMI and that, above 30 kg/m^2, it reduces 1% per unit of BMI[18]. Some authors have suggested that obesity may promote air trapping, which impairs adequate pulmonary ventilation through the reduction of pulmonary volumes[19]. Other authors find a connection between obesity and dyspnea when studying a group of older patients with higher BMI levels[20]. This study found that an aerobic exercise by brisk walking with swaying hips and hand weight load

Table 3 HRV of overweight and obese assessed during pre- and post-test among supine and tilt position in control and exercise groups

Position		Overweight group				Obese group			
		Control (n=15)		Exercise (n=16)		Control (n=15)		Exercise (n=17)	
		pre-test	post-test	pre-test	post-test	pre-test	post-test	pre-test	post-test
Supine	HR (bpm)	71 ± 9	70 ± 7	71 ± 7	63 ± 8***	72 ± 11	72 ± 11	69 ± 6	65 ± 6**
	Time domain								
	SDNN (ms)	48.1± 26.4	66.3 ± 34.4	65.1 ± 20.5	53.0 ± 21.7***	53.2 ± 31.7	49.0 ± 28.4	55.5 ± 20.5	51.7 ± 20.7
	RMSSD (ms)	50.6 ± 33.4	53.4 ± 38.1	43.4 ± 20.3	64.4 ± 32.5**	56.1 ± 52.6	49.7 ± 46.0	43.3 ± 17.7	55.3 ± 23.0**
	Frequency domain								
	LF (n.u.)	38.6 ± 16.8	33.5 ± 14.0	47.7 ± 20.8	33.5 ± 15.4***	39.2 ± 19.6	39.3 ± 19.6	44.7 ± 17.0	36.7 ± 15.2***
	HF (n.u.)	49.0 ± 18.8	53.7 ± 17.0	42.7 ± 18.7	59.8 ± 16.2***	46.6 ± 19.8	47.1 ± 19.8	44.9 ± 17.6	51.8 ± 15.5***
	LF/HF ratio	1.34 ± 0.85	0.94 ± 0.64	1.63 ± 1.25	0.71 ± 0.51***	1.33 ± 0.55	1.43 ± 0.66	1.43 ± 0.40	0.85 ± 0.64***
Tilt	HR (bpm)	86 ± 8	84 ± 9	85 ± 7	81 ± 11**	86 ± 11	86 ± 11	81 ± 10	76 ± 9***
	Time domain								
	SDNN (ms)	48.5 ± 28.4	48.6 ± 40.9	53.4 ± 34.5	38.7 ± 23.6***	45.4 ± 23.9	41.8 ± 23.9	68.5 ± 46.5	52.3 ± 33.1***
	RMSSD (ms)	34.6 ± 30.1	38.0 ± 31.5	24.3 ± 22.3	30.1 ± 27.1**	43.8 ± 34.7	40.9 ± 33.6	39.2 ± 40.6	56.6 ± 70.8***
	Frequency domain								
	LF (n.u.)	43.0 ± 20.7	39.7 ± 16.6	65.3 ± 18.3	57.2 ± 22.0***	45.8 ± 21.9	49.8 ± 20.4	52.8 ± 21.5	45.7 ± 21.3***
	HF (n.u.)	38.0 ± 12.4	41.7 ± 13.6	28.6 ± 16.4	34.0 ± 17.4***	38.3 ± 14.8	39.4 ± 15.7	33.4 ±14.2	39.5 ± 13.4***
	LF/HF ratio	1.96 ± 1.63	1.72 ± 1.49	3.46 ± 2.57	2.47 ± 1.86***	2.04 ± 1.23	2.23 ± 1.34	2.32 ± 2.15	1.58 ± 1.57***

HR, heart rate; SDNN, standard deviation of all NN intervals; RMSSD, square root of the mean of the sum of the squares of differences between adjacent NN interval; low frequency power (LF); high frequency power (HF); LF/HF ratio. Data are presented as mean ± SD. ** p<0.01 High significant difference and *** p<0.001 Highly significant difference in pre-versus post- test by paired t-test.

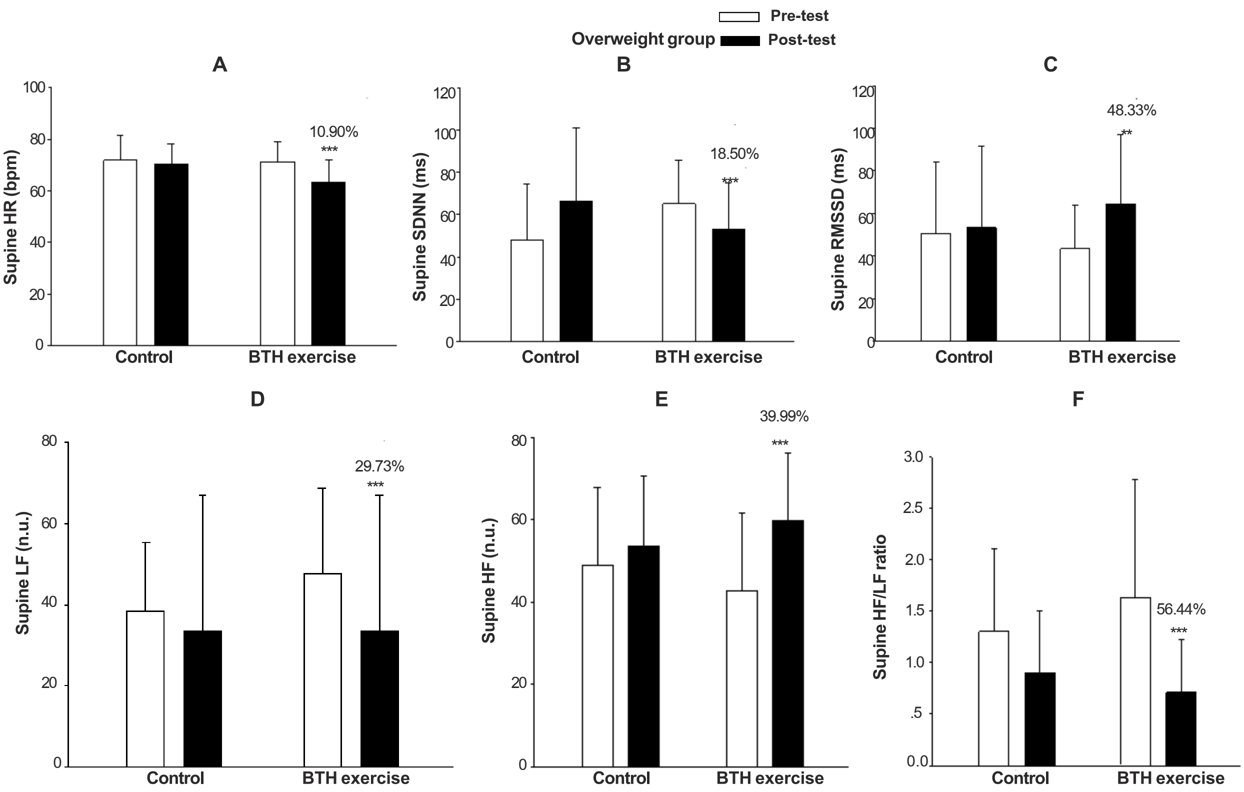

Figure 1 The measurements of (A) HR, (B) SDNN, (C) RMSSD, (D) LF, (E) HF, (F) HF/LF ratio in supine position during pre-test and post-test after 12 weeks of BWSHL exercise in overweight group (control, n = 15; exercise, n= 16). Data are shown as mean ± SD. ** p<0.01 High significant difference and *** p<0.001 Highly significant difference in pre-versus post- test by paired t-test.

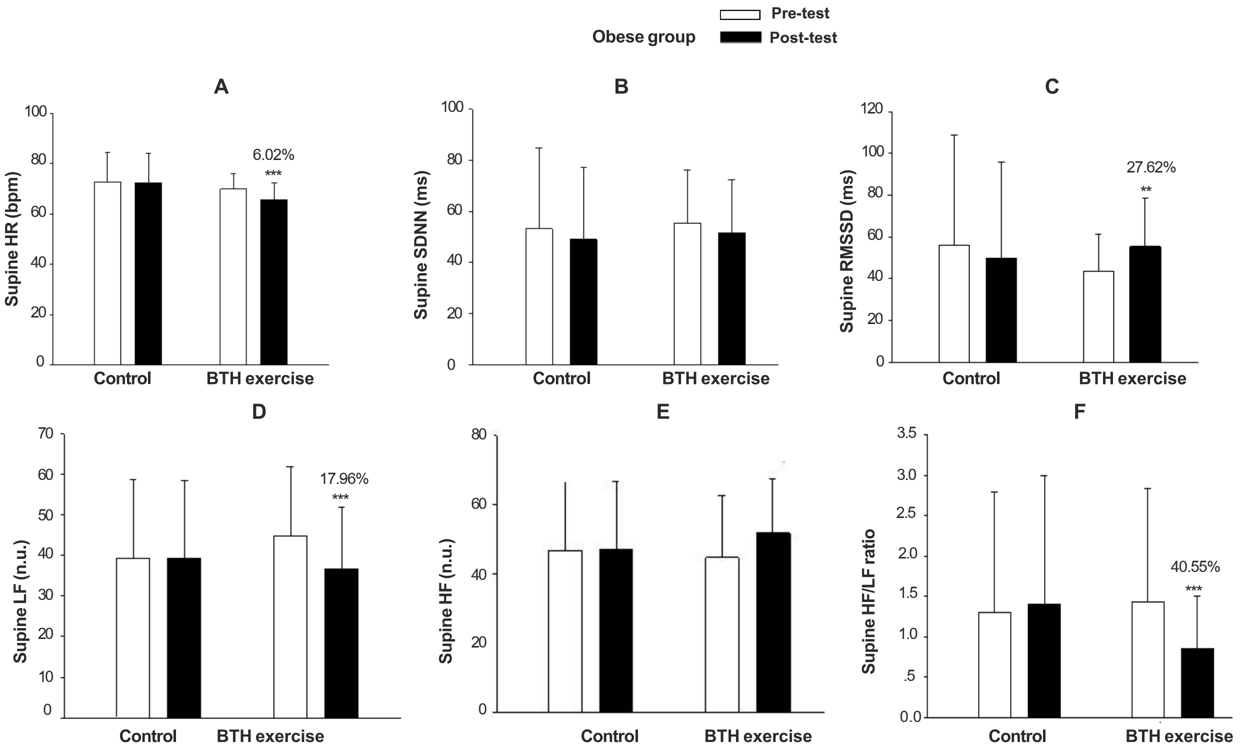

Figure 2 The measurements of (A) HR, (B) SDNN, (C) RMSSD, (D) LF, (E) HF, (F) HF/LF ratio in supine position during pre-test and post-test after 12 weeks of BWSHL exercise in obese group (control, n = 15; exercise, n= 17). Data are shown as mean ± SD. ** p<0.01 High significant difference and *** p<0.001 Highly significant difference in pre-versus post- test by paired t-test.

(BWSHL) had no effect on pulmonary function both overweight and obese Thai adults aged 20-35 years old.

BWSHL exercise and heart rate variability (HRV)

HRV of overweight and obese groups were significantly different between pre- and post-test in exercise groups. We found decrease in HR, SDNN, LF and LF/HF, and increase in RMSSD and HF in supine and tilt positions. Similarly, studies found that exercise training increases HRV[12, 13]. In contrast, a 12-week exercise training program by bicycling of 20 min/session, 3 sessions/week resulted in increased sympathetic activity in supine position and changes in HR upon changing postures from supine to upright was significantly greater than that of the pre-exercise[21]. Numerous studies show an increase in HRV, which indicates improvement of autonomic function by endurance exercise[22]. The discrepancy among various studies may be associated with difference in intensity, duration and mode of exercise program and individual subjects[23]

HRV is used to assess the cardiac autonomic function. Measuring autonomic activity using HRV provides a global assessment of sympathetic and parasympathetic contribution; thus, HRV may not be specific enough to detect subtle changes in autonomic control. Our results show an increase in parasympathetic, and a decrease in sympathetic activities following 12 weeks of aerobic exercise BWSHL in overweight or obese Thai adults show improvement of cardiac autonomic control.

Conclusions

This study shows that after 12 weeks of aerobic exercise of brisk walking with swaying hips and hand weight loading (BWSHL) cannot improve pulmonary function. However, it can improve in cardiac autonomic function (CAF) in overweight and obese Thai adults, aged between 20 to 35 years old.

Acknowledgements

This study was supported by grants from the Graduate School of Khon Kaen University, Khon Kaen, Thailand (Grant No. 56212106). We would like to thank Dr. Justin M. Reesefor English correction of the manuscript.

References

1. Speakman JR. Obesity: the integrated roles of environment and genetics. J Nutr 2004; 134: 2090S-2105S.
2. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. Geneva: WHO; 2000.
3. Aekplakorn W, Hogan MC, Chongsuvivatwong V, Tatsanavivat P, Chariyalertsak S, Boonthum A, et al. Trends in obesity and associations with education and urban or rural residence in Thailand. Obesity (Silver Spring) 2007; 15: 3113-21.
4. Faintuch J, Souza SA, Valezi AC, Sant'Anna AF, Gama-Rodrigues JJ. Pulmonary function and aerobic capacity in asymptomatic bariatric candidates with very severe morbid obesity. Rev Hosp Clin Fac Med Sao Paulo 2004; 59: 181-6.
5. Rasslan Z, Junior RS, Stirbulov R, Fabbri RMA, Lima CAC. Evaluation of Pulmonary Function in Class I and II Obesity. J Bras Pneumol 2004; 30: 508-14.
6. Chen Y, Horne SL, Dosman JA. Body weight and weight gain related to pulmonary function decline in adults: a six year follow up study. Thorax 1993; 48: 375-80.
7. Khrisanapant W, SengmeuangP, KukongviriyapanU, PasurivongO, PakdeechoteP. Plasma leptin levels and a restrictive lung in obese Thai children and adolescents. Southeast Asian J Trop Med Publ Health 2015; 46: 116-24.
8. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia 1985; 28: 412-9.
9. ACSM. American College of Sports Medicine. Guideline for Exercise Testing and Prescription. Med SciSports Exerc 2009; 17: 168-72.
10. Task Force. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Eur Heart J 1996; 17: 354-81.
11. Dumrongchua K, Tunkamnerdthai. Respiratory muscle strength and pulmonary function in sedentary Thais. Proc Grad Res Conf 2012: 829-37.
12. Iellamo F, Legramante JM, Massaro M, Raimondi G, Galante A. Effects of a residential exercise training on broreflex sensitivity and heart rate varibility in patients with coronary disease: A randomized, controlled study. Circulation 2000; 102: 2588-92.
13. Albinet CT, Boucard G, Bouquet CA, Audifferen M. Increased heart rate variability and exercise excutive performance after aerobic training in the elderly. Eur J Appl Physiol 2010; 109: 617-24.
14. Laszlo G. Standardisation of lung function testing: helpful guidance from the ATS/ERS Task Force. Thorax 2006; 61: 744-6.
15. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of lung function testing: the authors' replies to readers' comments. Eur Respir J 2010; 36: 1496-8.
16. Selvadurai, HC, Blimkie CJ, Meyers N, Mellis CM, Cooper PJ, Van Asperen PP. "Randomized controlled study of inhospital exercise training programs in children with cystic fibrosis. Pediatr Pulmonol 2002; 33: 194-200.
17. Costa D, Barbalho MC, Miguel GP, Forti EM, Azevedo JL. The impact of obesity on pulmonary function in adult women. Clinics (Sao Paulo) 2008; 63: 719-24.
18. Jones RL, Nzekwu MM. The effects of body mass index on lung volumes. Chest 2006; 130: 827-33.
19. Ladosky W, Botelho MA, Albuquerque JP, Jr. Chest mechanics in morbidly obese non-hypoventilated patients. Respir Med 2001; 95: 281-6.
20. El-Gamal H, Khayat A, Shikora S, Unterborn JN. Relationship of dyspnea to respiratory drive and pulmonary function tests in obese patients before and after weight loss. Chest 2005; 128: 3870-4.
21. Namarmarth J, Krisanapant W, Pasurivong O, Suthitum T. Impact of Exercise Training on Cardiovascular Autonomic Control in Obese Women. Khon Kaen: Khon Kaen University; 2011.
22. Rossi BR, Mazer D, Silveira LC, Jacinto CP, Di Sacco TH, Blanco JH, et al. Physical exercise attenuates the cardiac autonomic deficit induced by nitric oxide synthesis blockade. Arq Bras Cardiol 2009; 92: 31-8.
23. Boutcher SH, Stein P. Association between heart rate variability and training response in sedentary middle-aged men. Eur J Appl Physiol Occup Physiol 1995; 70: 75-80.