Respiratory muscle strength and pulmonary function in sedentary Thais

ความแข็งแรงของกล้ามเนื้อหายใจและสมรรถภาพปอดในประชากรไทยที่ออกกำลังกายไม่เพียงพอ

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ABSTRACT

Sedentary behaviors characterized by minimal movement, low energy expenditure and rest are an independent risk factor for developing health problems including obesity which may impair respiratory muscle strength (RMS) and pulmonary function (PF). We evaluated RMS and PF in 8 and 37 sedentary Thai men and women aged 20-55 yrs. Comparison between the 2 groups was also examined. RMS and PF measured by Vitalograph v.6 and MICRORPM®, Medical, UK were performed. The results showed that PImaxFRC, PImaxRV, PEmax, Pnsn and RMS were 87.2±14.6, 90.5±16.5, 94.3±16.38, 77.7±11.2 and 92.4 ± 15.4 cmH_2O in women and were lower than those of men ($P<0.05$). Moreover, VC, FVC, FEV_1, IRV and IC were also lower in women ($p<0.05$) whereas those predicted values were similar. In conclusions, the lower PF in sedentary Thai women was associated with lower RMS.

บทคัดย่อ

พฤติกรรมของผู้ที่ออกกำลังกายไม่เพียงพอซึ่งมีลักษณะมีการเคลื่อนไหวน้อย มีอัตราการใช้พลังงานต่ำและมักอยู่ในขณะพักเป็นปัจจัยเสี่ยงที่จะนำไปสู่ปัญหาต่อสุขภาพได้แก่ โรคอ้วนซึ่งอาจนำไปสู่ความแข็งแรงของกล้ามเนื้อหายใจและสมรรถภาพของปอดลดลง การทดลองนี้มีวัตถุประสงค์เพื่อวัดความแข็งแรงของกล้ามเนื้อหายใจและสมรรถภาพปอดในผู้ที่ออกกำลังกายไม่เพียงพอเป็นชาย 8 คนและหญิง 37 คน อายุ 20-55 ปี โดยเครื่อง Vitalograph และ MICRORPM® Medical, UK ผลการทดลองพบว่าเพศหญิงมีค่า PImaxFRC, PImaxRV, PEmax, Pnsn และ RMS เท่ากับ 87.2±14.6, 90.5±16.5, 94.3±16.38, 77.7±11.2 และ 92.4±15.4 cmH_2O ซึ่งต่ำกว่าเพศชาย ($p<0.05$) นอกจากนี้ยังพบว่า FVC, FEV1, IRV และ IC มีค่าต่ำกว่าเพศชาย ($p<0.05$) แต่มีค่าเปอร์เซ็นคาดคะเนไม่แตกต่างกัน โดยสรุปพบว่าค่าความแข็งแรงของกล้ามเนื้อหายใจที่ต่ำกว่ามีผลทำให้สมรรถภาพของปอดในหญิงต่ำกว่าในชาย

Key Words: sedentary, respiratory muscle strength, lung function
คำสำคัญ: ผู้ที่ออกกำลังกายไม่เพียงพอ ความแข็งแรงของกล้ามเนื้อหายใจ สมรรถภาพปอด

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Introduction

Modern lifestyles lead to few opportunities to be physically active and plenty of chances to be sedentary (Stamatakis and Hamer, 2011). Sedentary behaviours are characterized by minimal movement, low energy expenditure and rest (Shields and Tremblay, 2008). MET or the standard metabolic equivalent is a unit for estimating the amount of oxygen used by the body during a specific physical activity. One MET is the energy (oxygen) utilized by the body at rest, while sitting quietly or reading a book, for example. Activities that burn less than 1.5 METs, 1.5 to 3 METs, 3 to 6 METs and more than 6 METs are considered to be sedentary-, light-, moderate- and vigorous-intensity physical activities, respectively (Ainsworth et al., 2000). Previous studies over the last 10 years have indicated that sedentary behaviours are independent risk factors for several health outcomes and indicators of cardiovascular risk. There are abnormal glucose tolerance, metabolic syndrome, type 2 diabetes, some cancers, and cardiovascular risk factors, particularly obesity, 2-h glucose, and lipids (Dunstan et al., 2011). Physical inactivity, the fourth leading risk factor for global mortality, is seen worldwide, in high-income countries as well as low- and middle-income countries. World Health Organization (WHO) provides recommendations for the optimal amounts of activity, but doing some physical activity is better than doing none (Eveleth et al., 1998). Inactive people should start with small amounts of physical activity and gradually increase duration, frequency and intensity over time (Bijnen et al., 1994)

The prevalence of obesity is rising rapidly in most Asian countries. A recent study in 74,981 adults aged 20-50 years from all regions of Thailand has reported that domestic activities and sedentary behaviours are important in relation to obesity in Thailand, independent of exercise-related physical activity (Banks et al., 2011). 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). Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1) and vital capacity (VC) of the obese group were shown to be higher whereas FEV1/FVC ratio was lower than those of the non-obese group. Interestingly, maximal inspiratory pressure and maximal expiratory pressure were similar among the 2 groups (Charususin, 2007). Schoolchildren who are at risk of overweight or overweight and/or have more sedentary time have an increased risk of respiratory symptoms and asthma. Weight and sedentary statuses of schoolchildren can affect their respiratory health (Sengmeuang, 2010; Tsai and Tsai, 2009). Recently, obese women had higher respiratory muscle strength compared to normal weighted adults (Khrisanapant, 2011;Plaengdee, 2009). Studying peripheral muscle strength through the peak torque of knee extensors, and respiratory muscle strength (RMS) of 100 healthy subjects showed a positive correlation between both measures and the level of physical activity, regardless of the subjects' sex and age (Neder et al., 1999) Sedentary adolescents have lower RMS and lung function compared to those from Khon Kaen Sport School (Khrisanapant W, 2011). Up to date, there have been no studies conducted in sedentary adults especially in

Thais. The purpose of this study was therefore, to evaluate RMS and pulmonary function in Thais who were healthy but had sedentary lifestyles.

Materials and Methods

Study design and population

The study was analytical and descriptive and approved by the Human Research Ethics Committee, Khon Kaen University, and informed assent was obtained from each participant. Forty-five sedentary subjects of both genders aged between 23-55 years were recruited. All participant were completed a confidential health-screening questionnaire. Sedentary lifestyles were defined as not having engaged in more than 10 min at a time or 2 h of planned exercise per week. They were healthy with BMI of 18.5-24.9 kg/m^2 with history of non-regular alcohol drinking or smoking. Those having history of cardiovascular (i.e. hypertension, coronary heart disease, arrhythmia and chronic heart failure), neuromuscular, arthritic, pulmonary or other debilitating diseases or patients with severe microvascular diseases or diabetes mellitus were not included in this study.

Experimental Protocols

Participants were asked to have 3 visits to our Laboratory Unit: visit 1 Physical examinations & anthropometry; visit 2: measurements of RMS and lung function; visit 3: blood collection for fasting glucose, lipid profiles, and insulin.

Body mass index (BMI)

Height and weight were measured for each participant, according to the WHO guidelines. Participants wore light clothing and no shoes. Weight was determined using a digital scale (TCS-150-B), to the nearest tenth. Height was measured standing with feet together and arms relaxed at the sides. The BMI was calculated as weight (W, kg) divided by height (H, m^2).

Blood Chemistry

Blood chemistry was done to analyse lipid profiles, fasting glucose, insulin and complete blood counts. After a 12-hour fast, a venous blood sample, approximately 10 ml, was drawn from each participant. Aliquots of the sampled blood were stored for subsequent analysis of biochemical markers. Serum insulin levels were determined by immunoradiometric assay. Insulin resistance was estimated by Homeostasis Model Assessment (HOMA score). Insulin resistance was defined as the levels of the HOMA-IR greater than 3.16 (Keskin et al., 2005).

Respiratory Muscle Strength

MICRORPM®, Medical, UK was used to measure inspiratory and expiratory muscle strength. All participants underwent maximal inspiratory pressure at residual volume (PImaxRV) and at function residual capacity (PImaxFRC), sniff nasal pressure (Pnsn) and maximal expiratory pressure (PEmax) evaluation. All of procedures are referenced base on American/European Respiratory Society "ATS/ERS Statement on Respiratory Muscle Testing" (ATS/ERS, 2002). RMS was calculated as (PImaxRV+PEmax)/2.

Statistical Analyses

Data were expressed as mean ± standard deviation (SD). The significance of differences in characteristics and all parameters between men and women were analyzed by independent t-test or Two-sample Wilcoxon rank-sum (Mann-Whitney) test where data distribution was not normal. Statistical analyses were made using STATA version 10.0 (StataCorp, College Station, TX). P value less than 0.05 was considered to be statistically significant.

Results

Characteristics of sedentary subjects

Clinical and anthropometric characteristics of 45 sedentary subjects are summarized in Table 1.

Table 1 Subjects' characteristic

	Women (N=37)	Men (N=8)	p-value
Age (years)	33.4 ± 9.1 (32.0)	31.0 ± 11.5 (26.0)	NS[a]
Weight (kg)	52.5 ± 5.3 (52.0)	59.1 ± 6.2 (59.5)	<0.05[b]
Height (cm)	158.7 ± 6.2 (158.0)	167.6 ± 4.6 (168.5)	<0.05[b]
BMI (kg/m^2)	20.8 ± 1.6 (20.4)	20.9 ± 1.9 (20.7)	NS[a]
SBP (mmHg)	102.3 ± 8.2 (99.0)	109.0 ± 10.9 (107.0)	NS[b]
DBP (mmHg)	67.4 ± 7.6 (65.0)	74.3 ±10.2 (71.5)	NS[a]
HR (beat/min)	73.8 ± 8.0 (71.0)	70.4 ± 5.8 (69.5)	NS[a]

BMI, body mass index ; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate. Values are mean ± SD (median) tested by Mann-Whitney test[a] and independent t-test[b]

Biological risk factors

Serum lipid profiles, including total cholesterol, HDL, LDL, and triglycerides, fasting blood sugar, insulin level, HOMA-IR and complete blood count are presented in Table 2. TG level in men was significantly higher compared women by 68% ($p<0.05$).

Table 2 Lipid profiles, fasting blood sugar, insulin level, HOMA-IR and complete blood count.

	Women (N=37)	**Men (N=8)**	**p-value**
Cholesterol (mg/dl)	195.0±32.7 (195.0)	192.3±41.2 (189.0)	NS[a]
Triglyceride (mg/dl)	68.4±19.8 (66.0)	116.0±63.3 (106.5)	<0.05[b]
HDL (mg/dl)	66.1±12.6 (67.0)	60.0±13.8 (58.0)	NS[a]
LDL (mg/dl)	116.5±29.8 (118.0)	109.4±37.3 (104.5)	NS[a]
Glucose (mg/dl)	84.8±7.0 (84.0)	86.0±12.3 (87.0)	NS[a]
Insulin (uIU/ml)	11.1±5.2 (10.5)	10.8±5.8 (103.0)	NS[a]
HOMA-IR	2.3±1.1 (2.2)	2.4±1.6 (2.2)	NS[b]
RBC (10^6/uL)	4.5±0.5 (4.4)	5.3±0.7 (5.6)	<0.05[b]
Hb (g/dL)	12.4±1.0 (12.6)	14.2±1.1 (14.3)	<0.05[a]
Hct (%)	37.4±2.6 (37.8)	43.2±2.7 (43.1)	<0.05[a]
WBC (10^3/uL)	6.0±2.0 (5.4)	6.8±2.8 (5.9)	NS[b]
Plt (10^3/uL)	250.3±47.0 (240.0)	231.6 ±45.4 (246.5)	NS[a]

HDL, high density lipoprotein; LDL, low density lipoprotein ; HOMA-IR = fasting insulin (mIU/l) x glucose (mg/dl)/405; RBC, red blood cell; Hb, hempglobin; Hct, hematocrit; WBC, white blood cell; Plt, Platelets. Values are mean±SD (median) tested by independent t-test[a] and Mann-Whitney test[b].

There were no significant differences in cholesterol, triglyceride, HDL, LDL, glucose, fasting insulin and HOMA-IR. Complete blood count including RBC, Hb, Hct was significantly higher in men than those of women ($p<0.05$). It was observed that none of the participants revealed signs of hypercholesterolaemia, diabetes, anaemia, infection or insulin resistance.

Pulmonary function

The mean and median dynamic and static lung volumes are shown in Table 3. The results show that VC, FVC, FEV_1 were significantly higher than women by 42%, 40% and 42.5%, respectively ($P<0.05$). Moreover, IRV and IC in men were significantly greater compared to women (64% & 47%, $p<0.05$). There were no significant differences in predicted value of VC, FVC, FEV_1, IRV or IC.

Respiratory muscle strength

Table 4 and Figure 1 show respiratory muscle strength in sedentary women and men. By comparison with women, men had greater PImaxFRC, PImaxRV, PEmax and Pnsn by 50%, 44%, 52.8% and 24.5%, respectively ($p<0.05$). Accordingly, RMS in men was significantly higher compared to women by 27% ($P<0.05$).

Discussion

This is the first study to provide evidence of pulmonary function and respiratory muscle strength in both sedentary Thai men and women. They all had inactive life styles having no more than 10 min at a time or 2 h/wk of activities. Although, TG, RBC, Hb and Hct in men higher than in women, they all fell

Table 3 Lung function of study population

	Women (N=37)	Men (N=8)	p-value
VC (L)	2.7±0.4 (2.7)	3.86±0.56 (3.77)	<0.05[a]
VC (% pred)	92.5±11.3 (94.0)	97±9.21 (98.5)	NS[b]
FVC (L)	2.8±0.5 (2.7)	3.92±0.57 (3.8)	<0.05[a]
FVC (% pred)	94.1±10.5 (95.0)	99.25±9.84 (97.5)	NS[b]
FEV_1 (L)	2.4±0.4 (2.5)	3.42±0.49(3.59)	<0.05[b]
FEV_1 (% pred)	94.8±11.1 (94.0)	102.5± 9.7 (102.5)	NS[b]
FEV_1/FVC (L)	0.9±0.1 (0.9)	0.9±0.08 (0.9)	NS[b]
FEV_1/FVC (% pred)	97.8±18.0 (100.0)	101±9.04 (98.5)	NS[a]
VT (L)	0.8±0.3 (0.7)	0.8±0.09 (0.8)	NS[a]
IRV (L)	1.1±0.4 (1.0)	1.82±0.44 (1.9)	<0.05[b]
ERV (L)	1.1±0.4 (1.0)	1.39 ± 0.45 (1.4)	NS[a]
ERV (% pred)	93.1±41.9 (86.0)	95 ± 26.31 (100.0)	NS[a]
IC (L)	1.7±0.4 (1.7)	2.53±0.28 (2.4)	<0.05[b]
IC (% pred)	80.5±18.0 (79.0)	81.25±6.54 (81.0)	NS[a]

VC, vital capacity; FVC, forced vital capacity; FEV_1, forced expiratory volume in the first second; TV, tidal volume; IRV, insiratory reserve volume; ERV, expiratory reserve volume; IC, inspiratory capacity; % pred, % predicted value. Values are mean ± SD (median) tested by independent t-test[a] and Mann-Whitney test[b].

Table 4 Comparison of respiratory muscle strength in sedentary individual women and men

	Women (N=37)	Men (N=8)	p-value
PImaxFRC (cmH_2O)	87.2±14.6 (83.7)	120.7±12.5 (121.0)	<0.05
PImaxRV (cmH_2O)	90.5±16.5 (86.7)	122.5±20.6 (125.7)	<0.05
PEmax (cmH_2O)	94.3±16.38 (91.0)	144.7±20.8 (144.0)	<0.05
Pnsn (cmH_2O)	77.7±11.2 (75.3)	108.6±12 (98.7)	<0.05
RMS (cmH_2O)	92.4±15.4 (87.7)	118.2±49.7 (131)	<0.05

PImaxFRC, maximal inspiratory pressure from function residual capacity; PImaxRV, maximal inspiratory pressure at residual volume; Pnsn, sniff nasal pressure; PEmax, maximal expiratory pressure. Values are mean ± SD (median) tested by Mann-Whitney test.

into normal ranges of their own gender. None of them showed signs of overweight/obesity, hyperinulinaemia or insulin resistance, hypercholesterolnaemia, hypertension or diabetes. In comparison to women, men had higher VC, FVC, FEV1, IRV and IC. There is a marked sexual dimorphism in the structural and functional capacity of the pulmonary system. It has been suggested that sex differences in lung function can be explained by a fewer total number of alveoli

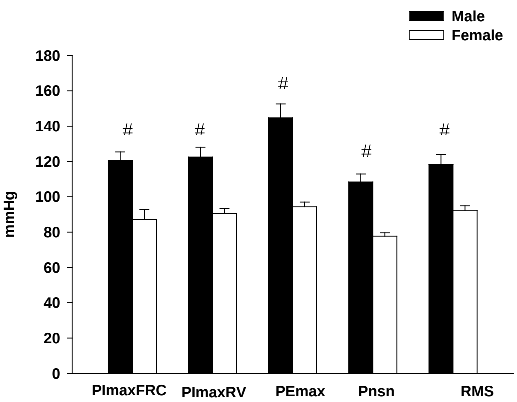

Figure 1 Comparisons in maximal inspiratory pressure from function residual capacity (PImaxFRC), maximal inspiratory pressure at residual volume (PImaxRV), maximal expiratory pressure (PEmax), sniff nasal pressure (Pnsn) and respiratory muscle strength (RMS) between men and women. Values are mean ± S.E.M., $^{\#}p<0.05$.

and smaller airway diameter relative to lung size in women in compared to men (Harms, 2006). Furthermore, clinical characteristics and biological risk factors were almost identical except that men were heavier and taller. It is, therefore, higher lung volumes were also due to higher weight and height. In term of %predicted values, there were no significant differences between the 2 groups as age, height and sedentary subjects have been already normalized. When compare our results to those of sedentary Australian men, it was found that the Australians had FVC and FEV_1 higher than sedentary Thai men by 92% and 28%, respectively (Eastwood et al., 2001). This is due to higher height and weight in the former. In addition, Khrisanapant and co-workers found that sport training students had greater lung volume than sedentary peers (Khrisanapant, 2011). They suggested performing regular activities help develop the greater lung volumes.

In regard to the respiratory muscle strength, we observed that PImaxFRC, PImaxRV, Psns and PEmax in men were higher than women. That inspiratory muscle strength was higher in men is in agreement with a previous study done in Brazilians (Simoes et al., 2011). They suggested that men were strongly and independently associated with higher values of maximal inspiratory pressure and the stronger respiratory muscle strength could be related to weight and height. The factors of sex differences for pulmonary function include hormone and morphology (Harms, 2006). Apparently, there was no sex difference in the elastic properties of the lungs (Rohrbach et al., 2003) and chest wall or pulmonary compliance (Johnson et al., 1993). Therefore, it is likely that the higher lung volumes in men are due to stronger respiratory muscle strength. In 2001, Eastwood and co-workers suggested that training background is the major factor by which endurance athletes achieve a greater (Eastwood et al., 2001).

Conclusions

Our study confirms previous studies regarding the higher lung volumes and respiratory muscle strength in sedentary Thai men compared to women. We suggest that effect of sex differences in lung function can be caused by a fewer total number of alveoli and smaller airway diameter relative to lung size in women and/or weight and height. A further study should be performed on larger scale of sedentary Thais and compare to those who are engaged to active lifestyle, e.g. athletes. We also aim to investigate whether introducing an aerobic exercise to sedentary Thais could improve lung function and respiratory muscle strength.

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