A Comparison of Respiratory Pressures in Normal Male and Female Thai Adults

การเปรียบเทียบแรงดันหายใจในประชากรไทยวัยผู้ใหญ่เพศชายและหญิง

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ABSTRACT

This study aimed to compare respiratory muscle strength (RMS) and its components between males and females aged 20 to 50 years old and to examine correlations between RMS and age. A total of 74 healthy subjects participated (37 males, 37 females). They were divided into three age brackets; 20-29, 30-39 and 40-50 years. PImaxFRC, PImaxRV, PEmax, Pnsn and RMS in males were 28.6%, 25.6%, 42.4%, 29.5% and 34.1% (20-29 yrs); 44.5%, 36.5%, 31.5%, 28.0% and 33.9% (30-39 yrs); 32.3%, 36.6%, 26.8%, 17.1% and 31.4% (40-50 yrs) ($p<0.01$), respectively, more than in females. Nevertheless, there were also no correlations of RMS with age in both genders. Moreover, the values for PImax and PEmax in Thai adults were relatively higher than in Caucasians. Data from this study could be used as preliminary data of respiratory muscle strength in Thai adults in the age of 20 to 50 years old.

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อหาความแตกต่างระหว่างความแข็งแรงของกล้ามเนื้อหายใจ (respiratory muscle strength, RMS) ในเพศชายและหญิง ที่มีอายุระหว่าง 20-50 ปี และหาความสัมพันธ์ระหว่างความแข็งแรงของกล้ามเนื้อหายใจ กับอายุ ในอาสาสมัครสุขภาพดี จำนวน 74 คน (ชายและหญิงกลุ่มละ 37 คน) แบ่งเป็น 3 กลุ่มอายุ ได้แก่ 20-29, 30-39 และ 40-50 ปี โดยพบว่าเมื่อเปรียบเทียบค่า PImaxFRC, PImaxRV, PEmax, Pnsn และ RMS ในผู้ชายมีค่ามากกว่าผู้หญิง (28.6%, 25.6%, 42.4%, 29.5% และ 34.1%; 44.5%, 36.5%, 31.5%, 28.0% และ 33.9%; 32.3%, 36.6%, 26.8%, 17.1% และ 31.4%) ($p<0.01$) ตามลำดับ แต่อายุไม่มีผลต่อความแข็งแรงของกล้ามเนื้อหายใจในทั้งสองเพศ นอกจากนี้ยังพบว่าความแข็งแรงของกล้ามเนื้อหายใจในคนไทยค่อนข้างมีความแข็งแรงกว่าชาวคอเคเซียน ข้อมูลที่พบครั้งนี้สามารถใช้เป็นข้อมูลพื้นฐานความแข็งแรงของกล้ามเนื้อหายใจในคนไทยที่มีอายุระหว่าง 20-50 ปี ได้

Key Words: Respiratory muscle strength, Gender, Age

คำสำคัญ: ความแข็งแรงของกล้ามเนื้อหายใจ เพศ อายุ

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Introduction

Respiratory muscle dysfunction is often associated with pulmonary complications, elevated morbidity and mortality (Iandelli *et al.*, 2001). Respiratory muscle assessment has been acknowledged as clinically relevant and respiratory muscle strength (RMS) is related to fitness and individual ventilatory capacity (Harik-Khan *et al.*, 1998; Rocha and Miranda, 2007). Weakness of this musculature consequently leads to reduced exercise tolerance and even respiratory insufficiency (Janssens *et al.*, 1999). The RMS can be measured by static and dynamic maneuvers, i.e. maximal inspiratory pressure (MIP or PImax), maximal expiratory pressure (MEP or PEmax) and sniff nasal inspiratory pressure (Pnsn) (Araujo *et al.*, 2012). These pressures measured through the mouth, except that of Pnsn, reflect the pressures that is being generated by the action of respiratory muscles (Chetta *et al.*, 2001). Clinically, RMS is measured as PImax and PEmax (Black and Hyatt, 1969; Evans and Whitelaw, 2009). It is a quick, sample, practical, low-cost and non-invasive method (Johan *et al.*, 1997). PImaxFRC and Pnsn reflect the strength of the diaphragm, while PImaxRV reflects the strength of the diaphragm and other inspiratory muscles. Additionally, PEmax reflects the strength of the abdominal muscles and other expiratory muscles (Costa *et al.*, 2010)

The relationship of these maximal pressures to age, sex, and general muscular development has been described (Black and Hyatt, 1969). Several studies have reported a negative correlation between age and RMS, i.e., 8 to 10% per decade from 40 years onwards (McConnell and Copestake, 1999; Neder *et al.*, 1999). In Thais, the RMS in females are 62 cm H_2O (40%), 63 cm H_2O (40%), 47 cm H_2O (34%) and 58 cm H_2O (43%), ($p<0.001$) less than in male in 30 to 39, 40 to 49, 50 to 59 and 60 to 70 years groups, respectively (Ponngeon, 2005). Furthermore, such a study has reported the relationship between RMS and age ranging from 30 to 70 years not including 20 to 29 years old.

Therefore, the purposes of the present study were to compare the RMS in males and females in the age group ranging from 20 to 50 years old and to investigate the relationship of respiratory pressures with age in healthy Thai adults.

Objectives of the study

The objectives of the study were to measure and compare respiratory pressures in males and females and to establish relationships between those pressures and age brackets from 20 to 50 years of age for population of healthy Thai adults.

Methodology

The study was analytical and descriptive approved by the Human Research Ethics Committee, Khon Kaen University. Each participant signed an informed assent form. Seventy-four healthy subjects of both genders (37 males and 37 females) were stratified into 3 age brackets: 20 to 29, 30 to 39, and 40 to 50 years). Number of subjects in both genders in each age bracket was equal. All subjects completed a confidential health and activity status questionnaire. They were healthy with BMI of 18.5-24.9 kg/m^2 having no history of regular alcohol drinking or smoking. Those having history of cardiovascular (i.e. coronary heart disease, arrhythmia and chronic heart failure), neuromuscular, arthritic and pulmonary diseases, patients with severe microvascular diseases,

diabetes mellitus, hypertension or other debilitating diseases were not included in this study.

Experimental Protocols

Body mass index (BMI)

Height and weight were measured for each participant, according to the WHO guidelines. Participants wore light clothing without shoes. Weight was determined using a digital scale, to the nearest tenth. 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).

Respiratory muscle strength

A 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) and Pnsn. Repetitions of measurement were performed at least 5 times with a one-minute interval in between, until the closed highest 2 values were achieved (at a difference of 5 or less between values for each repetition). The PEmax was obtained by breathing out from a total lung capacity, using the same methodology applied in the inspiration. During the PImaxFRC, PImaxRV and Pnsn maneuvers, the subject kept the mouthpiece in the oral cavity only during the inspiration and PEmax maneuver only during the expiration. All procedures are referenced base on American/European Respiratory Society "ATS/ERS Statement on Respiratory Muscle Testing" (ATS/ERS, 2002). The highest value was recorded. 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 males and females were analyzed by an independent t-test or a Two-sample Wilcoxon rank-sum (Mann-Whitney) test where data distribution was not normal. Analysis of variance (ANOVA) was used to determine differences among age brackets. If a significant F-ratio was obtained, then the post-hoc comparisons were made using the Tukey-Kramer test. Statistical analyses were made using STATA version 10.0 (StataCorp, College Station, TX). A value of $p<0.05$ was considered to be the threshold of statistical significance.

Results

Clinical characteristics of studied population

Table 1 shows clinical characteristics of males and females with different age brackets. Males in the 20 to 29 years group presented significantly higher height ($p<0.01$) compared to other age brackets. However, weight, body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure (MAP) and heart rate (HR) were not significantly different between age brackets. In females, the 30 to 39 years group had significantly higher weight ($p<0.05$), BMI ($p<0.01$), SBP ($p<0.01$), DBP ($p<0.01$) and MAP ($p<0.01$), compared to the others. Nevertheless, height and HR were not significantly different between age brackets. In addition, weight ($p<0.01$, $p<0.001$), height ($p<0.01$, $p<0.001$), SBP ($p<0.01$, $p<0.001$), DBP ($p<0.05$, $p<0.01$), MAP ($p<0.01$, $p<0.001$) and HR ($p<0.05$) were significantly different between genders but not BMI (Table 1). As can be seen, BMI and cardiovascular indices were within normal ranges which are indicative of being healthy (Table 1).

Table 1 Clinical characteristics of the study population by gender and age brackets.

	Males (n=37)			Females (n=37)		
	20-29 yrs	30-39 yrs	40-50 yrs	20-29 yrs	30-39 yrs	40-50 yrs
No of observation	15	9	13	15	9	13
Age (years)	24.1(1.7)	33.7(3.2)	44.2(2.4)^{c}	25.1(2.2)	36.6(3.7)	44.0(2.6)^{c}
Weight (kg)	65.5(10.3)^{¶a}	61.0(6.4)	65.1(4.5)$^{£a}$	52.1(5.8)	58.7(5.7)^{*c}	53.5(5.5)
Height (cm)	174.9(8.0)$^{£b}$	167.1(3.8)^{¶b}	168.4(3.6)^{**c}	158.7(8.2)	159.3(6.0)	155.8(5.3)$^{£b}$
BMI (kg/m^2)	21.2(2.1)	21.8(1.6)	23.0(1.7)	20.6(1.8)	23.0(1.2)^{**c}	21.9(1.7)
SBP (mm Hg)	123.5(8.7)^{¶a}	118.9(7.4)	125.1(4.3)	105.5(10.3)	118.9(8.5)^{**c}	109.8(9.6)
DBP (mm Hg)	74.7(6.6)$^{¥a}$	79.5(7.8)	79.5(5.2)^{¶a}	67.4(9.9)	79.4(8.3)^{**c}	69.6(7.1)
MAP (mm Hg)	90(6)^{¶a}	93(7)	95(4)$^{£a}$	80(9)	93(7)^{**c}	83(7)
HR (bpm)	76(8)	73(6)$^{¥b}$	75(5)	78(9)	79(7)	77(9)

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, Mean arterial pressure; HR, heart rate. Values are mean(SD). Data were tested by Mann-Whitney test[a], independent t-test[b] and Tukey-Kramer test (ANOVA)[c]. $^{*}p<0.05$ and $^{**}p<0.01$ significant effect between age brackets within the same gender. $^{¥}p<0.05$, $^{¶}p<0.01$ and $^{£}p<0.001$ significant effect between genders within the same age bracket.

Table 2 Comparisons of respiratory muscle strength between genders in different age brackets.

	Respiratory pressures (cm H_2O)				
	PImaxFRC	PImaxRV	PEmax	Pnsn	RMS
Males (n=37)					
20 -29 years	111.5(19.0)	121.4(17.7)	143.3(21.3)	109.8(21.9)	132.7(17.9)
30 -39 years	132.0(23.7)	137.4(24.0)	148.6(26.9)	116.3(23.9)	143.3(25.3)
40-50 years	114.9(21.7)	125.5(20.3)	134.6(14.8)	102.9(12.2)	130.1(17.2)
Mean(SD)	117.7(22.2)	126.7(20.6)	141.5(21.0)	109.0(19.8)	134.4(19.9)
Females (n=37)					
20 -29 years	86.7(15.4)	96.7(16.2)	100.7(18.1)	84.8(16.0)	98.9(16.7)
30 -39 years	91.3(16.4)	100.7(20.9)	113.0(22.3)	90.9(16.7)	106.8(21.3)
40-50 years	86.8(18.8)	91.8(16.6)	106.2(20.7)	87.8(16.1)	99.0(16.9)
Mean(SD)	87.9(16.5)**^{b}	95.9(17.4)^{**a}	105.6(20.2)^{**a}	87.3(15.9)^{**a}	100.9(17.8)^{**a}

Values are mean(SD). PImaxFRC, maximal inspiratory pressure at function residual capacity; PImaxRV, maximal inspiratory pressure at residual volume; PEmax, maximal expiratory pressure; Pnsn, sniff nasal inspiratory pressure; RMS, respiratory muscle strength. Data were tested by two-sample Wilcoxon rank-sum (Mann-Whitney) test[a], independent t-test[b]. $^{**}p<0.001$ males vs. females.

Respiratory muscle strength

Comparisons of RMS between males and females

Table 2 summarizes data in regard to RMS. It was observed that PImaxFRC, PImaxRV, Pnsn and PEmax in males were 29.8 cm H_2O or 33.9% ($p<0.001$), 30.8 cm H_2O or 32.1% ($p<0.001$), 21.6 cm H_2O or 24.8% ($p<0.001$) and 36.0 cm H_2O or 34.0% ($p<0.001$), respectively, greater than those of females. Besides, males had stronger respiratory muscles indicated by a RMS of 33.5 cm H_2O or 33.1% higher than that of females. However, PImaxFRC, PImaxRV,
Pnsn, PEmax and RMS were not significantly different between age brackets within the same gender (Table 2).

Relationships between RMS and age brackets in males and females

Table 3 depicts the relationships between RMS and age in males and females. It was found that PImaxFRC, PImaxRV, Pnsn, PEmax and RMS was not correlated with age in either males or females.

Discussion

PImax and PEmax are widely used, easily and non-invasive bedside tests. Our measurements were lower than those previously reported for adults (Black and Hyatt, 1969; Enright *et al.*, 1994; Wilson *et al.*, 1984).

The important finding of the present study was that males had higher RMS, e.g. PImaxFRC, PImaxRV, Pnsn and PEmax ($p<0.001$) of approximately 30 cm H_2O compared to those of females of the same age brackets. This is in agreement with a previous study done in Brazilians (44.0 cm H_2O or 53%, $p<0.001$), Chinese (40.1 cm H_2O or 66%, $p<0.05$), Malays (27.2 cm H_2O or 48%, $p<0.05$) and Indians (35.7 cm H_2O or 64%, $p<0.05$) (Costa *et al.*, 2010; Johan *et al.*, 1997) and in Thais (61.4 cm H_2O or 65%, 63.2 cm H_2O or 67%, $p<0.001$) in the 30 to 39 and 40 to 49 years age brackets (Ponngeon, 2005).

Males were strongly and independently associated with higher values of RMS (Harms, 2006). Similarly, Johan and coworkers (1997) observed that Chinese males had higher PImaxFRC, PImaxRV and PEmax compared to Malaysia and Indian males (Johan *et al.*, 1997). The greater RMS could be due to higher body weight and height in males as suggested by previous studies (Harms, 2006; Simoes *et al.*, 2011). Moreover, recent studies done in sedentary Thai (males) has reported PImaxFRC, PImaxRV, Pnsn, PEmax and RMS (33.5 cm H_2O or 38%, 32.0 cm H_2O or 35%, 30.9 cm H_2O or 40%, 50.4 cm H_2O of 53% and 25.8 cm H_2O or 28%), ($p<0.05$), respectively, higher than females (Dumrongchua, 2012). Similarly, Promsrisuk and colleagues (2013) observed that elderly Thai males had higher PImaxFRC, PImaxRV, Pnsn, PEmax and RMS (32.2 cm H_2O or 47%, 33.9 cm H_2O or 45%, 24.9 cm H_2O or 36%, 35.2 cm H_2O or 44% and 34.8 cm H_2O or 45%, $p<0.01$), respectively, compared to females (Promsrisuk *et al.*, 2013).

Furthermore, relationships between RMS and its components, and age were not observed in either males or females. The only study done in Caucasians with similar age group, e.g. 18 to 50 years old (Wilson *et al.*, 1984). They found that there was a significant negative correlation with age only in adult males not in females. A decline in RMS with increasing age in males has been demonstrated previously (Enright *et al.*, 1994; Johan *et al.*, 1997; Promsrisuk *et al.*, 2013; Wilson *et al.*, 1984). The reduction in inspiratory and expiratory muscle strength during the ageing process

could be a consequence of sarcopenia; the loss of muscle mass (Pride, 2005; Simoes *et al.*, 2010).

One group of authors (Watsford *et al.*, 2007) studied individuals of both genders in the 50 to 79 years bracket in Australia and observed that RMS was significantly lower in those in the 70 to 79 years age bracket than in those in the 50 to 59 years age bracket. According to a few studies, RMS decreases approximately 8 to 10% per decade from the age of 40 onward (Chan and Nathanson, 1989; Enright *et al.*, 1994). The decreased RMS is probably due to sarcopenia associated with ageing process (Enright *et al.*, 1994).

Certain limitations of this study must be considered. Firstly, the study was conducted in small numbers of participants to compare the RMS between males and females for 3 age brackets (20-29 yrs; n=15, 30-39 yrs; n=9, 40-50 yrs; n=13). Secondly, it is also recommended to extend the age brackets more than 3 age brackets. A further study in a large numbers of participants with more age brackets is necessary so that correlations for RMS and age, weight, height and BMI could be established.

Conclusions

Our study suggests higher respiratory muscle strength (RMS) in male compared to female Thai adults and no significant correlations for RMS and age. Moreover, it is crucial to conduct a further study on larger population with different age groups before confirming this finding.

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Table 3 Relationships between RMS and age in males and females.

	Males (n=37)			**Females (n=37)**		
	Equations	r	p	Equations	r	p
PImaxFRC (cm H_2O)	y = 0.28x + 108.4	0.1147	0.4991	y = 0.07x + 85.6	0.0352	0.8361
PImaxRV (cm H_2O)	y = 0.26x + 118.1	0.1149	0.4984	y = -0.16x + 101.4	-0.0798	0.6389
PEmax (cm H_2O)	y = -0.37x + 153.8	-0.1601	0.3439	y = 0.31x + 94.8	0.1364	0.4209
Pnsn (cm H_2O)	y = -0.26x + 117.7	-0.1212	0.4748	y = 0.18x + 81.1	0.0999	0.5564
RMS (cm H_2O)	y = -0.05x + 136.0	-0.0278	0.8703	y = 0.08x + 98.1	0.0327	0.8478

Abbreviations are as in Table 2.

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