ORIGINAL ARTICLE

Correlation of Thorax Expansion with Heart Rate and Blood Pressure in School-Aged Children

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ABSTRACT

Background: Thorax expansion used to measure respiratory function. Data of thorax expansion for healthy children is still limited. Thorax expansion is caused by breathing. This influences cardiovascular function because anatomically the heart is located within the thorax cavity. The aim of this study is to determine the measurement of thorax expansion using the measurement tape method. Factors influencing thorax expansion are sex and age; and correlates with heart rate and blood pressure in school age children.

Methods: Ninety-six children were included in this study both male and female and were aged 6 to 15 years. They were in Elementary School and Junior High School in Jatinangor. The study were conducted from September-November 2013 by adopting a random selection cross sectional method. The examinations performed after written informed consent and questionnaire form from their parents.

Results: The results showed that upper thorax has lower mean expansion than middle and lower thorax expansion respectively (2.96±0.64cm; 3.82±1.04cm; 5.01±1.15cm). There was significant difference between groups of age ($p<0.05$). This study also found that there was a correlation between the upper and middle thorax expansion with the heart rate ($r=0.35$; $p=0.001$, and $r=0.32$; $p=0.002$).

Conclusions: The mean of thorax expansion at upper, middle and lower respectively (2.96±0.64cm; 3.82±1.04cm; 5.01±1.15cm) are influenced by age and has correlation with heart rate.

Keywords: *blood pressure, heart rate, school-aged children, thorax expansion.*

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INTRODUCTION

Thorax expansion is associated with chest wall mobility as a result of respiratory muscle function that is influenced by age and sex type.[1-4] Thorax expands to decrease intrapleural pressure during breathing.[5] The development of thorax in school age children and adult produces different normal values. The normal value for school age children is inconclusive due to limited studies. Thorax expansion measurement is used to diagnose, monitor of disease progression, and assess treatment effectiveness.[3,4] Thorax expansion can be measured by measurement tape, which is inexpensive, reliable, straight-forward, easy to learn and apply, and appropriate for used in clinical settings.[2-4]

Ventilation affects the cardiovascular function through an interaction among myocardial reserve, ventricular pump function, circulating blood volume, blood flow distribution, autonomic tone, endocrinology responses, lung volume, intrathorax pressure, and the surrounding pressure of the circulation.[6] Pulmonary system and the heart lies within the same thorax cavity and become subjects of intrathoracic pressure changes.[7] Thorax expansion is generated when the lungs inflate and compress the heart where they lay within a closed thorax cavity.[6,7] Thorax expansion affects cardiac output, both diastolic and systolic pressures.[6,8] The goals of this study are to measure thorax expansion that is influenced by age and sex using measurement tape method in school age children, and determine it's correlation with blood pressure and heart rate.

METHODS

This study was performed after geting approval from the ethical clearance committee. There were 96 out of 219 children who passed the inclusion and exclusion criteria. They were healthy males and females aged 6 to 15 years old. Respondents were recruite from the Elementary School 2 of Cikeruh and Junior High School 1 of Jatinangor, using random selection cross sectional method. This study was conducted between September and November 2013. The children had have their parents agreed to participate in this study and were given questionnaires to fill regarding their children's pre-existing conditions. The main purpose of the questionnaire was to collect demographical datas on characteristics, health conditions, medication consumption, smoking status, everyday activities, and puberty level of the children. Children who did not return the questionnaire form were excluded from the study.

The inclusion criteria includes healthy children aged 6 to15 years old, both males and females with normal body weight based on according to data from the Health Ministry of the Republic of Indonesia. The Children age sorted and then they were divided into two groups. The first group was children aged 6 to 10 years old, and the second was 11 to 15 years old. The exclusion criterias were children with: A) respiratory and cardiovascular disorder; B) abnormal spine, thorax or upper extremity; C) history of smoking, D) history of surgery on the chest. Those who were unwell on the day of examination were also excluded from this study to avoid misinterpretation.

Every children had 15 minutes of examination in the classroom. Measurement of body height and weight were performed with minimal clothes and without shoes. The circumference of the thorax during thorax expansion was measured at the end of maximal inspiration and end of maximal expiration. The value recorded was the difference between measurement at the end of maximal inspiration and end of maximal expiration.

They had to be bare-chested during examination. Their arms were elevated for maximal contraction of the pectoralis and latissimus dorsi muscles. Thorax expansion was measured at three levels, first, at the fifth spinous process of thoracic vertebrae and third intercostals space at midclavicular line; second, at the sixth spinous process of thoracic vertebrae and fourth intercostals space; and third, at the tenth spinous process of thoracic vertebrae and xyphoid process. Maximum of three times of measurement were given to every children. If they did not follow the instruction to breathe well, they had to be excluded.

Three fingers paralel to the thumb were used to measure the pulsa rate of radial artery at the wrist for fifteen seconds. The number of pulse multiplied by four if the pulses were regular and recounted for 60 seconds if the pulse was suspected to be irregular. While also auscultation to the heart beat using a stethoscope. Children's blood pressures were measured using a sphygmomanometer and a stethoscope. The cuff size must be suitable for the children's upper arm. The cuff length must fit 75% of the upper arm. The children were then requested to sit down and relax their arms.The arms were put on table at the level of heart. The cuff was positioned at approximatly 3 fingers or 2.5 cm from antecubital crease. The index finger and middle finger of examiner must be placed on the radial artery, then pump the bulb until the pulse dissapear per palpation. After the pulse dissapear, then slowly empty the cuff. A stethoscope was placed at brachial artery and the bulb was pumped until the pulse of radial artery dissapeared plus 30 mmHg. Measurements were taken three times from each arm.

The obtained data was statistically analyzed using Mann-Whitney non-parametric test because there were anomalies distribution of data. Data statistically significant when $p \leq 0.05$. Measurement results of thorax expansion were compared between the two groups based on age and sex. The correlations between thorax expansion, blood pressure, and heart rate were assessed using Spearman test.

RESULTS

Different values of thorax expansion were recorded between the three levels of measurement in 96 school age children, both males and females.

Table 1. Normal Circumference of Thorax Expansion

Characteristics	Thorax Expansion (cm)		
	Upper	Middle	Lower
Mean ± SD	2.96 ± 0.64	3.82 ± 1.04	5.01 ± 1.15
Median	3.0	4.0	5.0
Min-Max	2.0-4.0	1.5-6.0	3.0-8.0

*SD: Standard deviation

Based on Table 1, thorax expansion at upper level had less mean value than middle and lower levels.

Table 2. Thorax Expansion Data in Each Groups of Age and Sex

Characteristic Thorax Expansion	Male	Female
Age 6-10 years old	n = 23	n = 25
Upper (cm)		
Mean ± SD	2.78 ± 0.65	2.86 ± 0.69
Min-Max	2.0-4.0	2.0-4.0
Middle (cm)		
Mean ± SD	3.37 ± 1.17	3.70 ± 1.01
Min-Max	1.5-6.0	2.0-5.5
Lower (cm)		
Mean ± SD	4.50 ± 1.16	4.92 ± 1.37
Min-Max	3.0-7.5	3.0-8.0
Age 11-15 years old	n = 24	n = 24
Upper (cm)		
Mean ± SD	3.17 ± 0.55	3.04 ± 0.62
Min-Max	2.0-4.0	2.0-4.0
Middle (cm)		
Mean ± SD	4.21 ± 0.99	3.98 ± 0.84
Min-Max	3.0-6.0	3.0-6.0
Lower (cm)		
Mean ± SD	5.42 ± 0.87	5.17 ± 0.97
Min-Max	3.0-6.0	3.5-8.0

* n: number of samples; SD: Standard Deviation; Min: Minimal; Max: Maximal

Based on Table 2,The mean of thorax expansion at 6-10 years has lesser than 11-15 years.

Table 3 shows the differences of thorax expansion for groups of age and sex. The significant difference was found between the group of age (p= 0.031, p= 0.019, p= 0.005) but not significant differences at different sex.

Table 3. Thorax Expansion Differences For Each Group

Group	Thorax Expansion		
	Upper	Middle	Lower
Age	z=-2.156	z=12.344	z=-2.807
	p=0.031	p=0.019	p=0.005
Sex	z=-0.188	z=-0.201	z=-0.074
	p=0.851	p=0.841	p=0.941

Table 4. Correlation between Thorax Expansion with BP And HR

Thorax Expansion	Systolic BP	Diastolic BP	HR
Upper	r = 0.011	r = 0.113	r = -0.345
	p = 0.917	p = 0.272	p = 0.001
Middle	r = -0.025	r = 0.011	r = -0.317
	p = 0.81	p = 0.916	p = 0.002
Lower	r = -0.001	r = 0.128	r = -0.196
	p = 0.991	p = 0.215	p = 0.055

*HR: Heart Rate; BP: Blood Pressure; L: Level Thorax Expansion

The correlation of thorax expansion with heart rate and blood pressure in each group were calculated. Based on the data in table 4, that has negative correlation between upper and middle thorax expansion with heart rate and has significant correlation.

DISCUSSION

The data obtained by the present study represent the establishment of normal range of thorax expansion in healthy school age children. It is impossible to compare the result with previous studies. The interpretation of normal thorax expansion has variation, the values from other populations as reported in the literature cannot be extrapolated because lungs are known to be different across race and ethnic groups.[3]

Based on Table 1, thorax expansion at the upper level has lower mean value than the middle and lower levels. Mean ± standard deviation for upper, middle, and lower thorax expansion respectively are 2.96±0.64 cm, 3.82±1.04 cm, 5.01±1.15 cm. These are because the main muscles of respiration, the external and internal intercostal muscles and diaphragm that lies in chest wall, constructs the rib cage.[5] The expansion of upper and middle thorax are limited to the costal bone, except the lower thorax where no bones laid is measured for the expansion of diaphragm and abdominal compartment.[1]

This study results are paralel to the hypothesis that sex and age affect thorax expansion value[1-3]. The 6-10 years old group shows lower mean value than the 11-15 years old group. It is affected by the height and weight of children, which are increase with age.[1]

The age group of 6-10 years old shows higher number of females than males. However, the group of age 11-15 years shows number of males greater than females. Moreover, in correlation to the 11-15 years old group in different gender, previous study found that the lung volume in adult female is smaller (10-12%) than male who have the same height and age.[1]

The statistic analysis of Mann-Whitney test on Table 3 shows that thorax expansion is influenced only by age ($p<0.05$) significantly, nonetheless, sex type factor does not significantly affect thorax expansion value. Different activities among children may affect the result.[4] It is suggested that the aggravating factors to thorax expansion value include low socioeconomic level, low birth weight and less daily activities.[3]

Thorax expansion in relation with blood pressure and heart rate (Table 4) shows negative significant correlation between upper and middle thorax expansion with heart rate ($r= -0.345$, $p= 0.001$ and $r= -0.317$, $p= 0.002$).

The interpretation of negative correlation coefficient (r) between thorax expansion and heart rate means that high thorax expansion produces slower heart rate. This condition is because the heart lies within the upper thorax, at the level of fifth spinous process of thoracic vertebrae and third intercostal space at midclavicular line.[9]

Previous study shows increased pleural pressure affects both diastolic and systolic pressure.[8] Pleural pressure is increasing during respiration and can be measured by thorax expansion. Nevertheless, the present study finds blood pressure has no correlation with the diastolic and systolic pressures ($r<0.3$ and $p>0.05$). Many factors influencing pleural pressure are increased in blood pressure, heart rate, stroke volume, blood viscosity, and peripheral resistance.[9] If any of these factor changes, the blood pressure would also change continue as normally as possible. Blood pressure usually changes as response to changes in cardiac output. Increase cardiac output that increase blood pressure.[6, 9]

Cardiac Output (CO)=
Stroke Volume (SV) x Heart Rate (HR)

Blood pressure in children is influenced by activity, body weight, gender and energy consumption.[10,11] Systolic and diastolic blood pressures vary by 10 mmHg from lowest to highest level of activity.[11]

The limitation of this study were the sample were only healthy population and only small number. It is recommended to conduct a future study in a larger population and make a comparison study between the healthy group and group with diseases to seek the different mobility level of thorax expansion and the correlation with heart rate and blood pressure in both groups. A suggested future study can be performed in obese children, to find any associations between fat level and thorax expansion. The children activities could be assessed too in order to find the correlation between daily activities and level of thorax expansion.

CONCLUSION

Thorax expansion at upper thorax level has lower mean value in comparison with the middle and lower thorax expansion value. Thorax expansion influenced by age in healthy school age children. Finally, the upper and middle thorax expansion shows stronger correlation with heart rate than lower thorax expansion.

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