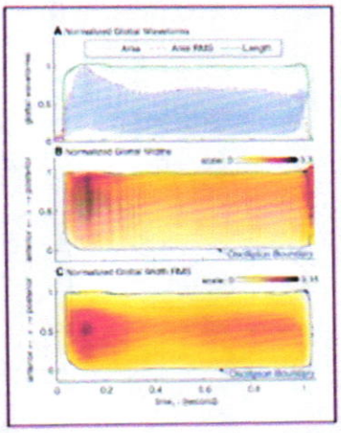
JOURNAL OF VOICE



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Calendar

NOVEMBER 2016

12th Pan European Voice Conference

Dates: August 30th-September 1st, 2017

Location: Ghent, Belgium

Brief description: PEVOC12 wants to provide an international forum for all voice experts from the pedagogical, artistic, medical and scientific areas, offering them the opportunity to exchange knowledge and to present past experiences and/or challenging innovative creations. For the first time, this outstanding conference takes place in Ghent (Belgium) a marvelous historical city and also a vivacious contemporary one, under the Patronage of Her Majesty, the Queen of the Belgians!

Featured speakers/faculty: See the website for up-to-date information.

Registration fee: $430 Early Bird / $490 Regular / $560 Late / $660 On Site

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Lung Vital Capacity of Choir Singers and Nonsingers: A Comparative Study

*Abyan Irzaldy, †Sundari Indah Wiyasihati, and †Bambang Purwanto, *†*Surabaya, Indonesia*

Summary: Objectives. The popularity of choir singing among Indonesian university students as an extracurricular activity has increased in the last few years. Choir singers use physiology principles especially respiration roles in the voice production process. This research aims to determine the lung vital capacity difference between singers and nonsingers.

Methods. This is a cross-sectional study which uses primary data collected from spirograms of 20 university students. Half of the students were Airlangga University choir singers, and the other half were students who are not members of the choir. The spirometry tests were performed to obtain inspiratory capacity, vital capacity, and forced vital capacity of both groups.

Results. The average lung vital capacity of choir singers was higher (3.12 L) than that of the nonsingers (2.73 L). The average inspiratory capacity of the singer group was 1.79 L, and the average inspiratory capacity of the nonsinger group was 1.71 L. The lung vital capacity difference between singers and nonsingers group was statistically significant ($P = 0.02$). There was no significant inspiratory capacity difference between singers and nonsingers group in this study ($P = 0.611$). The forced vital capacity measurement showed a significant difference ($P = 0.01$) between singers (75.28%) and nonsingers (68.14%).

Conclusion. It can be understood that the increasing vital capacity in choir singers is most likely from the expiration phase of the respiration. Further studies need to be conducted to confirm the causes of the increasing vital capacity in singers.

Key Words: Vital capacity–Inspiratory capacity–Choir–Singer–Spirometry.

INTRODUCTION

Choir is the oldest type of musical group in the world. Before the invention of musical instruments, people used human voice as a way to perform music collectively. The variation of frequencies of human voice enables people to sing collectively in different frequencies. The role of respiration in producing human voice is pivotal. Airflow is needed to vibrate the vocal folds. This fact implies that singers undergo physiological changes especially in the process of producing voice.

In Indonesia, choir activity is one of the most popular extracurricular activities among youngsters. Many Indonesian choral groups, mainly from youth communities, have won various international choral competitions. It is most likely a possible reason of the increasing popularity of choir activity among Indonesians. It can be inferred that the more people joining choir also means that the more people experiencing physiological changes especially in the respiratory system.

Vital capacity is the sum of inspiratory reserve volume, expiratory reserve volume, and tidal volume. This is also a maximum air volume that a human can inhale and exhale in one single breath. Maintaining an ideal vital capacity is important because of the fact that the larger the vital capacity, the better oxygen level can be maintained. Oxygen level is crucial to maintain the function of most tissues in the human body especially brain tissue.[1]

Previous studies about the effects of various kind of training in lung function showed different results. A study of a group of middle-aged obese men who had undergone low-intensity aerobic training obtained a bigger lung vital capacity.[2] Another study observed that bigger lung vital capacity, residual volume, and total lung capacity were obtained by scuba divers who had undergone 5-week respiratory training program.[3]

Most of research about lung vital capacity that has already been conducted has mainly discussed the relationship between vital capacity and diseases, the effect of doing various kinds of sports on lung vital capacity, and lung vital capacity as an alternative diagnosis method. The effects of common and light activities such as singing on lung vital capacity are relatively rare to be observed. Therefore, this research aims to determine the lung vital capacity difference between choir singers and nonsingers.

METHODS

A cross-sectional study was performed to observe the effect of choir singing exercise on lung vital capacity. Two groups of students were involved in this research. The first group consisted of 10 university male choir singers who met a few criteria such as minimum of 2 years choir membership and trainings, minimum of twice weekly choir trainings, nonsmokers, and not having respiratory problems and diseases. The second group was defined as a control group that consisted of 10 university male students who meet a few criteria such as not a member of choir groups, nonsmokers, not having any choir training or other activities which use vigorous respiration training for minimum of 2 years, and not having respiratory problems and diseases. To ensure that the students met the criteria, a questionnaire was used (see Table 1).

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TABLE 1.
Criteria of the Volunteers

Group of Singers	Group of Nonsingers
Male	Male
Nonsmoker	Nonsmoker
Having minimum of 2 years choir membership and training sessions	Not a member of any choir group
Having minimum of twice weekly choir training sessions	Not having any choir training for minimum of 2 years
Not having any respiratory problems and diseases	Not having any respiratory problems and diseases
Not having routine activities which use vigorous respiration training other than choir for minimum of 2 years	Not having routine activities which use vigorous respiration training for minimum of 2 years

After the preparation of the volunteers, a one-stage spirometry test was performed to obtain vital capacity and inspiratory capacity of all the volunteers. Vital capacity was measured from the end of inspiration until the end of expiration to see the expiration capability of students, whereas inspiratory capacity was measured from the beginning of inspiration until the end of inspiration. Age and height of the students were also observed to analyze these two variable effects on this research.

After the completion of spirometry test, the results were analyzed using SPSS 17. The statistical test performed was the independent *t* test which is useful for comparing the data means.

RESULTS

Both groups have the same age average (20.7 years old). The average height of the singer group is 169.6 cm, whereas for the nonsinger group, it is 167.2 cm. Slightly higher average heights of the singer group potentially affect lung vital capacity measurement. Therefore, the independent *t* test was performed. The result is that there is no significant difference for the average heights between the two groups ($P = 0.222$).

Vital capacity measured in the singers group is higher than that in the nonsingers group. The average vital capacity in singers group is 3.12 L (standard deviation [SD], 0.35), whereas the average vital capacity in nonsingers group is 2.73 L (SD, 0.32). Statistically, the lung vital capacity difference between the two groups is significant ($P = 0.02$). Forced vital capacity (FVC) is another variable measured in this study, the average FVC in singers group is 75.28%, whereas the average FVC in nonsingers group is 68.14%. The FVC measurement results show significant difference ($P = 0.01$) (see Table 2).

There is no significant inspiratory capacity difference between the two groups ($P = 611$). The average inspiratory capacity in the singers group is 1.79 L (SD, 0.51), whereas for the nonsingers group, it is 1.71 L (SD, 0.39) (see Figure 1).

DISCUSSION

Factors affecting lung vital capacity

There are several factors that can affect lung vital capacity measurement in humans. They are posture, age, sex, physical build, pregnancy, and physical training.[4] In this research, the measured factors are age and height although all students involved in this research are male. The habit of singing among the singers is probably equivalent to physical training factor because of its frequent use of respiratory muscles involved in producing voice.

Age obviously can affect lung vital capacity of the human. The older a person, the more likely a decline in lung function happens.[5] Energy needs continue to increase until the age of 40 years when the physical strength decreases.[6] The decreasing physical strength in older people can obviously affect the activity of respiratory muscles. In this research, the age factor is unlikely to affect the lung vital capacity measurement because both groups have the same age average (20.7).

As for height, there is a linear correlation between height and vital capacity.[7]

The taller a person, the bigger probability he or she will have a bigger thorax. The height measurement in this study shows that there is no significance difference between the two groups ($P = 0.222$). Therefore, it is unlikely that the slight height difference between the two groups could give a major impact on lung vital capacity measurement.

There is a vital capacity difference between men and women. Men usually have larger lung volumes than women due to men's relatively bigger lungs. Besides, the higher adipose tissue in women could give an impact as muscle tissues need a bigger amount of oxygen than adipose tissue. In this study, all students who were observed are male to avoid measurement bias because of vital capacity difference between men and women.

The increasing lung vital capacity in singers

Respiration is undeniably crucial in producing voice, especially in singing. Singing involves a fast and strong inspiration followed by prolonged and controlled expiration. People who sing are practicing a particular exercise which requires diaphragm contraction to do inspiration followed by prolonged contraction of respiratory muscles to vibrate the vocal folds. Therefore, singers need an accurate breathing adjustment.[8]

When we breathe normally, in the end of inspiration, the diaphragm relaxes followed by a passive expiration caused by lung recoil force. However, expiration will become an active process when the ventilation increases because of obstructed airflow. This is what happens when singing and speaking. Expiratory muscles play important roles in singing, coughing, defecating, and parturition.[9] In producing voice, if airflow is weak and inadequate, the voice produced will be weak. For example, people

TABLE 2.
Results of Variables Measurement

	Nonsingers Group				Singers Group			
Variables	Mean	Min	Max	Standard Deviation	Mean	Min	Max	Standard Deviation
Age (y)	20.7	18	24	1.77	20.7	19	21	0.82
Height (cm)	167.2	160	175	4.92	169.6	165	177	3.44
Inspiratory capacity (L)	1.71	1.15	2.39	0.39	1.79	1.20	2.545	0.51
Vital capacity (L)	2.73	2.29	3.34	0.32	3.12	3.09	3.54	0.35
FVC (%)	68.14	64.7	74.22	0.04	75.28	63.24	85.61	0.07

Abbreviation: FVC, forced vital capacity.

who suffer from emphysema, lung cancer, asthma, or other lung diseases often have difficulties in speaking loudly for a long period.[10]

The functions of inspiration and expiration are important in singing. However, expiration is most likely to play a bigger role in producing voice. Expiration is very important in the effort of vibrating the vocal folds to produce voice. It may be the reason why in this study, the mean vital capacity in singers group is significantly bigger than in the nonsingers group.

The increasing strength of expiratory muscles is a probable reason of the increasing vital capacity in the singers group. In a condition where the function of the muscle is increasing or decreasing, muscle remodeling happens. In the context of muscle tissue as a contractile tissue, muscle mass and muscle extensibility affect muscle strength. The increasing muscle mass or usually called muscle hypertrophy is caused by the increasing number of actin and myosin in each muscle fiber. Significant hypertrophy occurs when the muscles are given load during contraction. In the case of increasing vital capacity in choir singers, the increasing muscle extensibility is more likely to be happening than the increasing of muscle mass. The increasing muscle extensibility followed by the increasing length of muscles forms new sarcomeres in the end of muscle fibers which are attached to the tendons.[11] This causes expiratory muscles in the singers to become elastic and not stiff.

Whereas, in the context of muscle tissue as an excitable tissue, neuromuscular junctions and neurotransmitters give effects to muscular adaptation in training. In choir singing exercises, repeated stimulus happens to respiratory muscles. Physiological changes in neuromuscular junction also happen. The length of nerve terminal branching increases, the complexity of nerve terminal branching also increases then followed by the increasing numbers of presynaptic vesicles. The increasing number of presynaptic vesicles increases the amount of acetylcholine.[12,13]

There is some research which discussed the effect of doing sports on lung vital capacity. A study in people who attend yoga class found an increasing vital capacity in people who do yoga class regularly.[14] Another study found that people who play badminton have bigger lung vital capacity than those who do not. The similarity between badminton and choir singing is that these activities use respiratory muscles.

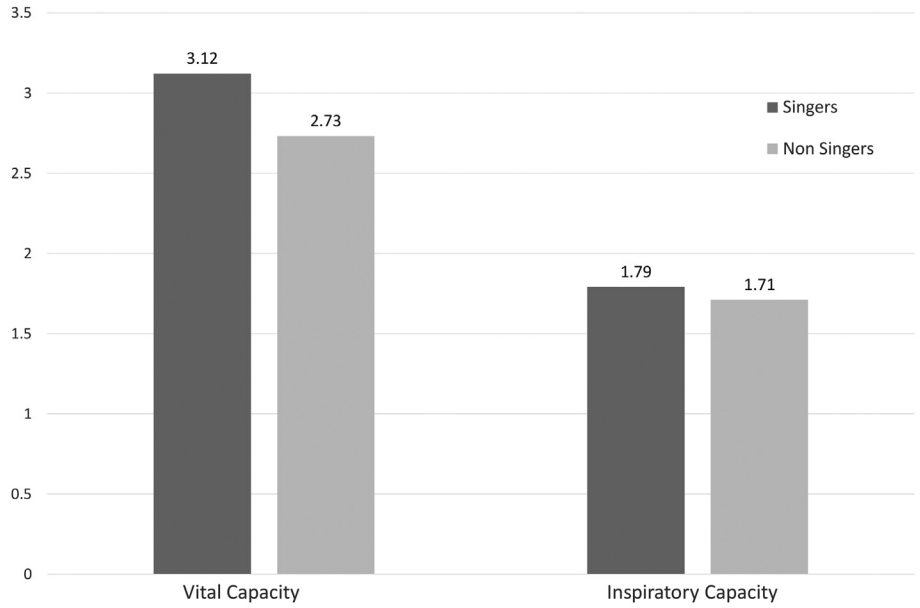

FIGURE 1. Vital capacity and inspiratory capacity comparative chart.

Badminton players use abdominal muscles such as rectus abdominis.[15] Another study observed a group of old women who accomplished 8 weeks respiratory muscle training obtained a significant forced vital capacity increase compared to the control group.[16]

However, the argument which claims that the singers have stronger inspiratory or expiratory muscles compared to the nonsingers needs to be studied further. Measurements of maximal expiratory pressure and maximal inspiratory pressure need to be conducted to obtain data regarding the respiratory muscles strength.

Inspiratory capacity measurement

The inspiratory capacity is the sum of tidal volume and inspiratory reserve volume. On the basis of the previous study, inspiratory muscles training can increase vital capacity and total lung capacity.[17] Whereas in this study, there was no significant difference between the inspiratory capacities of both groups although the average inspiratory capacity in singers was slightly higher. As mentioned previously, the expiration muscles are responsible in regulating airflow to produce voice via vocal fold vibration. It may be the reason why the difference between both groups is mainly in the vital capacity which represents the expiration ability due to its measurement which started in the end of inspiration until the end of expiration. The inspiration is unlikely to show a significant difference as most physiological changes in singers happen in expiration phase of the respiration.

CONCLUSIONS

In this study, there was a significant difference in the vital capacity between both groups, whereas inspiratory capacity measurement showed no significant difference. It can be concluded that bigger lung vital capacity measurement in the singers is most likely because of the bigger volume of air exhaled in the expiratory phase of the respiration. Future research should be focused on measuring more variables such as maximal expiratory pressure and maximal inspiratory pressure to compare the respiratory muscles strength between singers and nonsingers. This report is also unable to exclude the possibility that the singers have bigger lung vital capacity to start with. Long-term experimental studies need to be conducted to confirm the effect of singing training by comparing the initial singers' lung vital capacity and the singers' lung vital capacity after the training sessions.

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REFERENCES

1. Riggs S. More on brain and lung health: vital capacity. *NACD J*. 2012;25:1.
2. Muralikrishna M, Shelvam PV. Effect of different intensities of aerobic training on vital capacity on middle-aged obese men. *Int J Curr Res Aca Rev*. 2014;2:85–90.
3. Fisher CW, Gibson AL. Five-week respiratory muscle training program effects on lung function and air consumption in SCUBA divers [Internet]. Powerlung studies and papers (US). Available at: http://www.powerlung.com/region/us/information/studies/five-week-respiratory-muscle-training-program-effects/. Accessed April 29, 2015.
4. Pal GK. *Textbook of Practical Physiology*. 2nd ed. New Delhi: Orient Longman Private Limited; 2006.
5. Suyono Joko. *Deteksi Dini Penyakit Akibat Kerja*. Jakarta: EGC; 1995.
6. Anugrah Yuma. Factors that related to vital capacity in miling workers in Batu Putih Division of PT. Sinar Utama Karya. *Unnes J Public Health*. 2014;3:18 [Indonesian].
7. McDonnell WF, Seal E Jr. Relationships between lung function and physical characteristsics in young adult black and white males and females. *Eur Respir J*. 1991;4:279–289.
8. Bonilha AG, Onofre F, Vieira ML, Prado MY, Martinez JA. Effects of singing classes on pulmonary function and quality of life of COPD patients. *Int J Chron Obstruct Pulmon Dis*. 2009;4:1–8.
9. Marek Dan. *Singing: The First Art*. Lanham, MD: Scarecrow Press; 2007.
10. The Voice Foundation (US). *Breakdown Results in Voice Disorder [Internet]*. Philadelhipa, PA: The Voice Foundation (US); 2014. Available at: http://voicefoundation.org/health-science/voice-disorders/anatomy-physiology-of-voice-production/breakdowns-result-voice-disorders/. Accessed January 10, 2015.
11. Guyton AC, Hall JE. *Textbook of Medical Physiology*. 11th ed. Philadelphia, PA: Elsevier Saunders; 2006.
12. Fahim MA. Endurance exercise modulates neuromuscular junction of C57BL/6NNia aging mice. *J Appl Physiol*. 1997;83:59–66.
13. Rudolf R, Khan MM, Labeit S, Deschenes MR. Degeneration of neuromuscular junction in age and dystrophy. *Front Aging Neurosci*. 2014;6:99.
14. Birkel DA, Edgren L. Hatha yoga: improved vital capacity of college students. *Altern Ther Health Med*. 2000;6:55–63.
15. Nagarajoo, Devi Suguuna. Lung vital comparation between badminton players and non-players in Cikal Medan in 2011 [Internet]. USU Institutional Repository (ID). Available at: http://repository.usu.ac.id/handle/123456789/31340. Accessed January 10, 2015.
16. Watsfon Mark, Murphy Aron. The effect of respiratory-muscle training on exercise in older women. *J Aging Phys Act*. 2008;16:245–260.
17. Enright S, Chatham K, Lonescu A. Inspiratory muscle training improves lung function and exercise capacity in adults with cystic fibrosis. *Chest*. 2004;2:405–412.