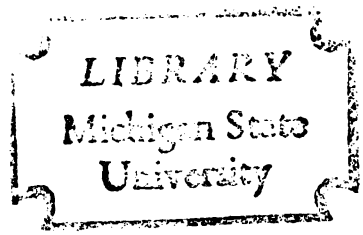


This is to certify that the

dissertation entitled

A STUDY OF LUNG CAPACITIES IN
WIND INSTRUMENTALISTS AND VOCALISTS

presented by

EDWARD J. HUTTLIN

has been accepted towards fulfillment
of the requirements for

M.M. degree in Music

Merrell L. Shoemaker
Major professor

Date 11-2-81

A STUDY OF LUNG CAPACITIES IN WIND INSTRUMENTALISTS AND VOCALISTS

By

Edward J. Huttlin

A THESIS

Supplementary to Three Trombone Recitals

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Doctor of Philosophy

Department of Music

1981

ABSTRACT

A STUDY OF LUNG CAPACITIES IN
WIND INSTRUMENTALISTS AND VOCALISTS

By

Edward J. Huttlin

Although wind instrumentalists and vocalists use their lungs vigorously while performing, few studies have been published measuring the size of their vital capacities. The objectives of this study were to:

1) Compare the vital capacities of instrumental and vocal musicians with those of a control group.

2) Compare the vital capacities of performers on different instruments.

3) Measure the variation in capacities of men and women who play the same instrument.

4) Determine the effects of smoking on the wind musician's lung capacity.

The 376 subjects in this study were enrolled in accredited universities at the sophomore, junior, or senior level, in the 18-23 age range, and in good health. The control group consisted of 90 students who had no previous training on a wind instrument or in voice, and the experimental group consisted of 286 students who were

music majors with voice or a wind instrument as their major performance area. Members of the experimental group were expected to be in good standing in their respective departments, and only instrumentalists who played approximately fourteen hours a week or more, and vocalists who sang approximately seven hours a week or more, were considered for this study.

The test consisted of recording information related to the subject's age, height, weight, sex, smoking habits, practice habits, and general health, and then measuring the subject's vital capacity. This measurement was compared against a predetermined norm based on the subject's height, and the percentage difference was calculated. The mean percentages of the various groups and subgroups were tabulated and compared.

The data collected suggest the following conclusions:

1) The vital capacities of the wind instrumentalists and vocalists generally appear to be larger than those of the control subjects.

2) Brass instrumentalists seem to register higher increases than members of either the vocal or woodwind groups.

3) Men and women who play the same instrument appear to register similar variances from their predicted values.

4) Smoking appears to only slightly decrease the vital capacity of the performer's lungs.

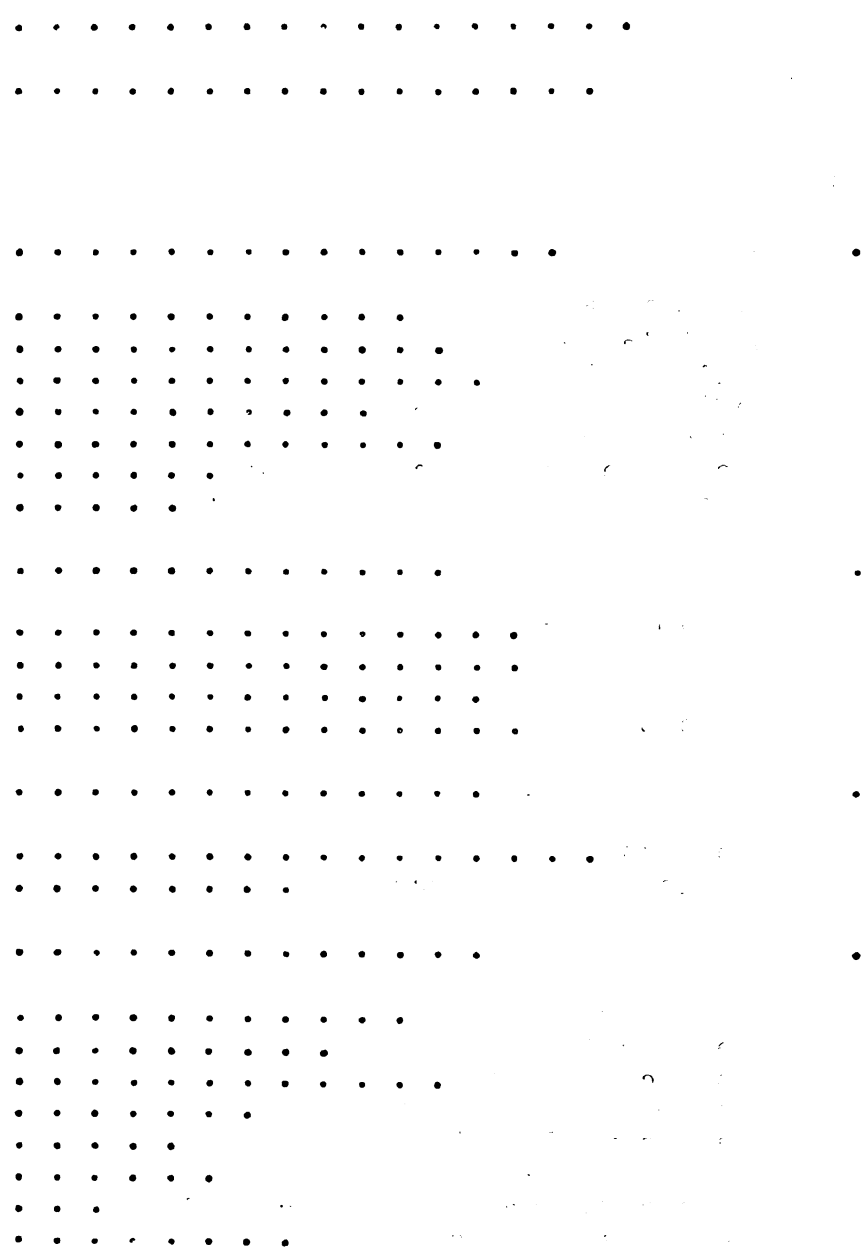
This study was performed by an instrumental teacher and performer seeking information in an area where little published data is available.

PREFACE

As an instrumental teacher and performer, rarely a private lesson or practice session goes by without some attention being given to the breath in relation to musical performance. Phrases like "take a deeper breath" and "give more breath support" are a part of almost every instrumental and vocal teacher's vocabulary; however, upon asking several music teachers whether vocalists and wind instrumentalists have larger lung capacities than other people, a variety of answers was given. A search for published literature on this subject did not provide satisfying results, and this inspired the topic for this paper. The conclusions reached should be viewed from the standpoint that they are not those of a physiologist or trained statistician, but rather those of a curious musician.

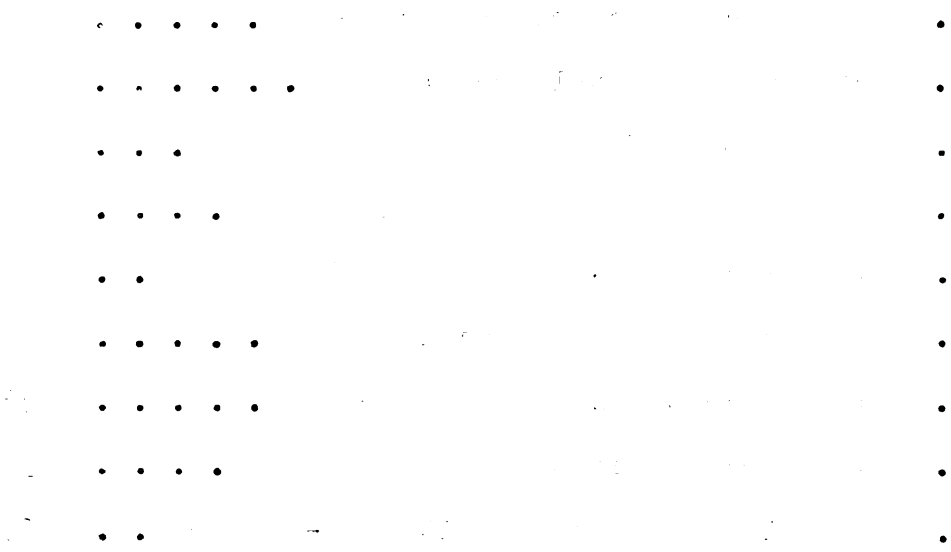
Appreciation is expressed to Dr. Merrell Sherburn, Professor of Music at Michigan State University, for his interest, suggestions, and encouragement throughout this project. Thanks is given to Dr. John Close, Professor of Music at Concordia College, for assisting in the analysis and presentation of the data. Gratitude is also expressed to Dr. Ivan Johnson, Professor of Physiology at Concordia College, for reviewing the paper.

TABLE OF CONTENTS

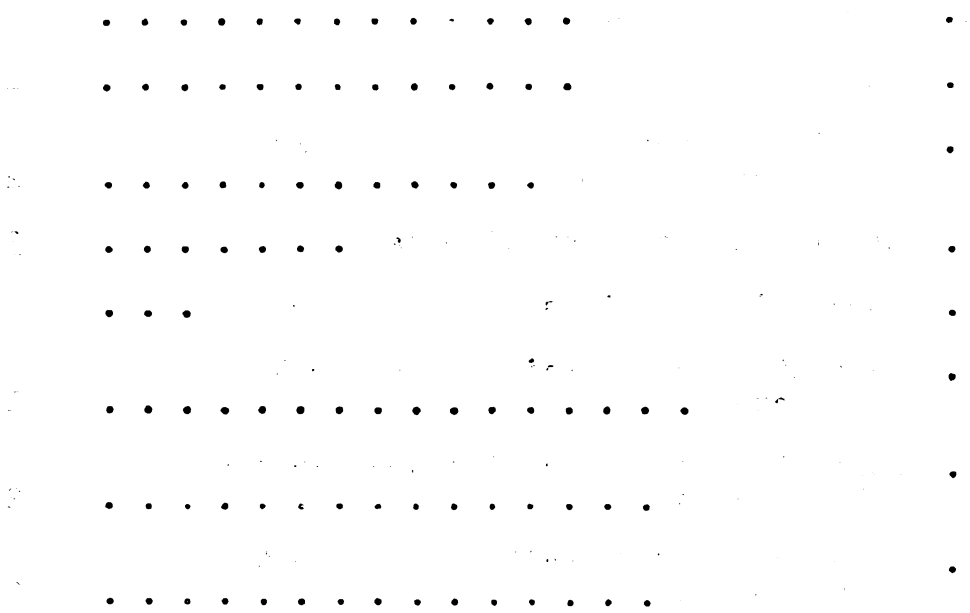


LIST OF TABLES

Table



LIST OF FIGURES



Chapter 1

THE PROBLEM

General Statement

Wind instrumentalists and vocalists probably use their lungs more vigorously than people in other professions. However, no comprehensive study has been documented which gives a detailed analysis of the existing differences, if any, in terms of the vital capacity of their lungs.

In treatises and articles on performance many chapters have been written discussing breathing, but traditional ideas and personal viewpoints pervade these writings, with little reference being made to controlled experimentation. Vocal pedagogy techniques are most often cited in musicians' discussions of breathing, and these references are rarely based on anything other than empirical observation. Within these writings there is also much disagreement regarding the function of the muscles in the throat, the movement of the internal organs, and the proper use of the respiratory system in instrumental and vocal teaching. In an article on respiration and wind instrument performance, Kenneth Berger comments on the numerous erroneous statements found in instrumental treatises written by performers, indicating a general

misunderstanding of the lungs in terms of musical performance.[1]

It is the author's belief that through controlled studies of lung capacities of wind instrumentalists and vocalists, one can get a better understanding of the effects of vocal and instrumental performance on the lungs, which in turn will lead to improved instrumental and vocal teaching.

Specific Problem

The focal point of this study will be a comparison of the lung capacities of instrumentalists and vocalists with those of individuals with no instrumental or vocal training. The data accumulated will be directed toward the following questions: 1) is there a difference in lung capacities between the instrumental/vocal musicians and the control group, 2) do capacities vary between performers of different instruments, 3) is there a variation in the capacities of men and women who play the same instrument, and 4) does smoking have an effect on a performer's lung capacity.

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[1] Berger, Kenneth. "Respiratory and Articulatory Factors in Wind Instrument Performance," Journal of Applied Physiology, Vol. 20, 1965, p. 1217.

Delimitations

All subjects in this study were enrolled in an accredited university at the sophomore, junior, or senior level, in the 18-23 age range, and in good health. Subjects were limited to this group because studies by Lim[2] and Grollman[3] note a change in lung capacities at different ages, and the 18-23 age range is generally considered among the prime years in terms of physical health and vital capacity of the lungs.

The control group consisted of both music majors and non-majors who had no previous training on a wind instrument or in voice. Some members of the control group, however, did study wind instruments and/or voice in a classroom situation as part of the requirements for a degree in music education, although no extensive performance or practice routine was ever undertaken.

The experimental group was limited to students seeking an undergraduate degree in music who had studied applied music on their major instrument at the college level for a minimum of 1½ consecutive years. Students who seriously performed on two or more instruments were eliminated from the experimental group to avoid confusion

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[2]Lim, Thomas. Cardiopulmonary Function Tests in Clinical Medicine, Springfield, Illinois: Charles Thomas Publishers, 1966, p. 166.

[3]Grollman, Sigmund. The Human Body, New York: MacMillan and Company, 1964, p. 286.

in classification. The instrumentalists and vocalists were required to be in good standing in their respective departments, and only instrumentalists who played at least 14 hours a week, and vocalists who sang at least 7 hours a week, were considered for the study. An attempt was made to get students from different colleges and universities in the experimental group so that many teaching approaches and philosophies were represented.

Because of studies by Crosbie,[4] Ekblom,[5] Magel,[6] and Wilmore[7] indicating that extensive physical activity can increase one's lung capacity, students who were members of organized sports teams or participated in rigorous physical fitness programs involving swimming, jogging, or similar activities, were not included in either the control or experimental group. Neither group contained any subjects with bronchial asthma, emphysema, or similar respiratory disorders.

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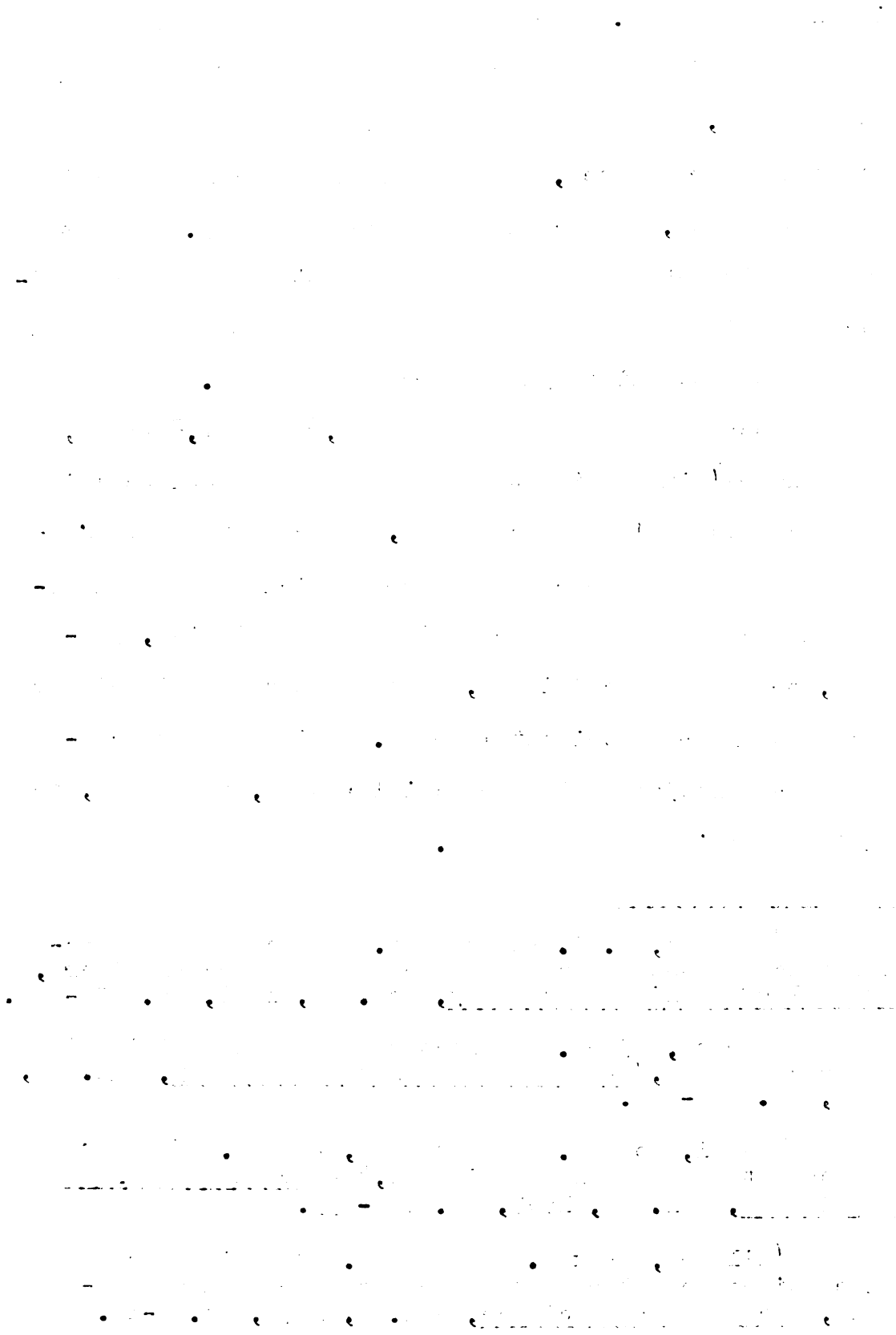
[4]Crosbie, W. A. and others. "Functional Characteristics of the Large Lungs Found in Commercial Divers," Journal of Applied Physiology, Vol. 46, 1979, pp. 639-645.

[5]Ekblom, Bjorn. "Effect of Physical Training in Adolescent Boys," Journal of Applied Physiology, Vol. 27, 1969, pp. 350-355.

[6]Magel, John R. and Faulkner, John A. "Maximum Oxygen Uptake of College Swimmers," Journal of Applied Physiology, Vol. 22, 1967, pp. 929-933.

[7]Wilmore, Jack J. and others. "Physiological Alterations Resulting from a Ten Week Program of Jogging," Medicine and Science, Vol. 2, 1970, pp. 7-14.



Definition of Terms

Vital Capacity. "The greatest possible inspiration followed by the expiration of all the air within the lungs that is voluntarily possible."[8]

Smoker. An individual who presently smokes and has smoked cigarettes or other tobacco substances daily for a period of two years or more.

Non-Smoker. A person who has not smoked in two years and who has never smoked daily for a period of one year or more.

Basic Hypothesis

The researcher believed that wind instrumentalists and vocalists have larger lung capacities in comparison to the average person. This belief resulted from the fact that wind instrumentalists and vocalists use their lungs more vigorously than laymen. The average person takes 16 breaths a minute, whereas musical phrases often require the performer to breath less frequently.[9]

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[8]Bass, B. H. Lung Function Tests, London: H. K. Lewis and Company, 1974, p. 8.

[9]Carlson, Anton and others. The Machinery of the Body, Chicago: University of Chicago Press, 1972, p. 262.

Studies by Kory,[10] Bass,[11] and Baldwin[12] indicated a direct correlation between height and lung capacity, and this was assumed. These same studies indicated that women have smaller capacities than men, and this was anticipated. It was also expected that smokers would have smaller lung capacities than non-smokers, since studies by Higgens,[13] Krumholz,[14] and McDermott[15] pointed to this conclusion.

Procedure in Collecting Data

A sampling of the lung capacities of wind instrumentalists and vocalists was randomly collected and compared with a sampling of the lung capacities of subjects with no wind instrument or vocal training. An attempt

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[10]Kory, R. C. and others. "The Veterans Administration - Army Cooperative Study of Pulmonary Function," American Journal of Medicine, Vol. 30, 1961, pp. 243-258.

[11]Bass, op. cit., pp. 86-87.

[12]Baldwin, E., Cournand, A., and Richards, D. "Pulmonary Insufficiency," Medicine, Vol. 27, 1948, pp. 243-278.

[13]Higgens, I. T. "Tobacco Smoking, Respiratory Symptoms, and Ventilatory Capacity. Studies in Random Samples of the Population," British Medical Journal, 1959, pp. 325-329.

[14]Krumholz, R. A. and others. "Cardio-pulmonary Function in Young Smokers," Internal Medicine, Vol. 60, 1964, pp. 603-610.

[15]McDermott, M. and others. "Acute Effects of Smoking on Lung Airways Resistance in Normal and Bronchitis Subjects," Thorax, Vol. 20, 1965, pp. 562-569.

was made to acquire measurements of at least ten subjects on every instrument.

The sex, age, height, weight, and smoking habits of the subjects were recorded and lung capacities measured. A Phipps and Berg wet spirometer No. 7087-100 was chosen for the testing because of its portability and ease of resetting. The subjects were asked to take a full breath and expire completely into the mouthpiece of the spirometer. This procedure was repeated three times, with an average computed to assure that an accurate reading had been recorded.

Procedure in Treatment of Data

Averages of the lung capacities of each subject were calculated and measured against a predicted capacity based on one's height. The data collected was divided into brass, woodwind, vocal, individual instrument, and control groups, and then further subdivided into male-female and smoker-non-smoker sets. The averages and percentiles for each category were compared against each other and differences were discussed. The lung capacities of wind instrumental performers and vocalists were categorized, and as a result of this research, the effects of instrumental and vocal performance on the vital capacity of a sample group of college age musicians was determined.

Chapter 2

RELATED LITERATURE

Although the spirometer has been in existence for over one hundred years, it has received little use for purposes other than clinical medical studies on people with lung disorders. Wind musicians and vocalists, who use their lungs actively in performing, have had few lung function studies performed on them with the exception of ones by Stanley S. Heller,[16] Kenneth Berger,[17] Arend Bouhuys,[18] and John Large.[19] The Heller study was performed in New York and published in 1960, the Berger study was performed in Ohio and published in 1965, the Bouhuys study was performed in the Netherlands and published in 1964, and the Large study was performed in Los Angeles and published in 1971.

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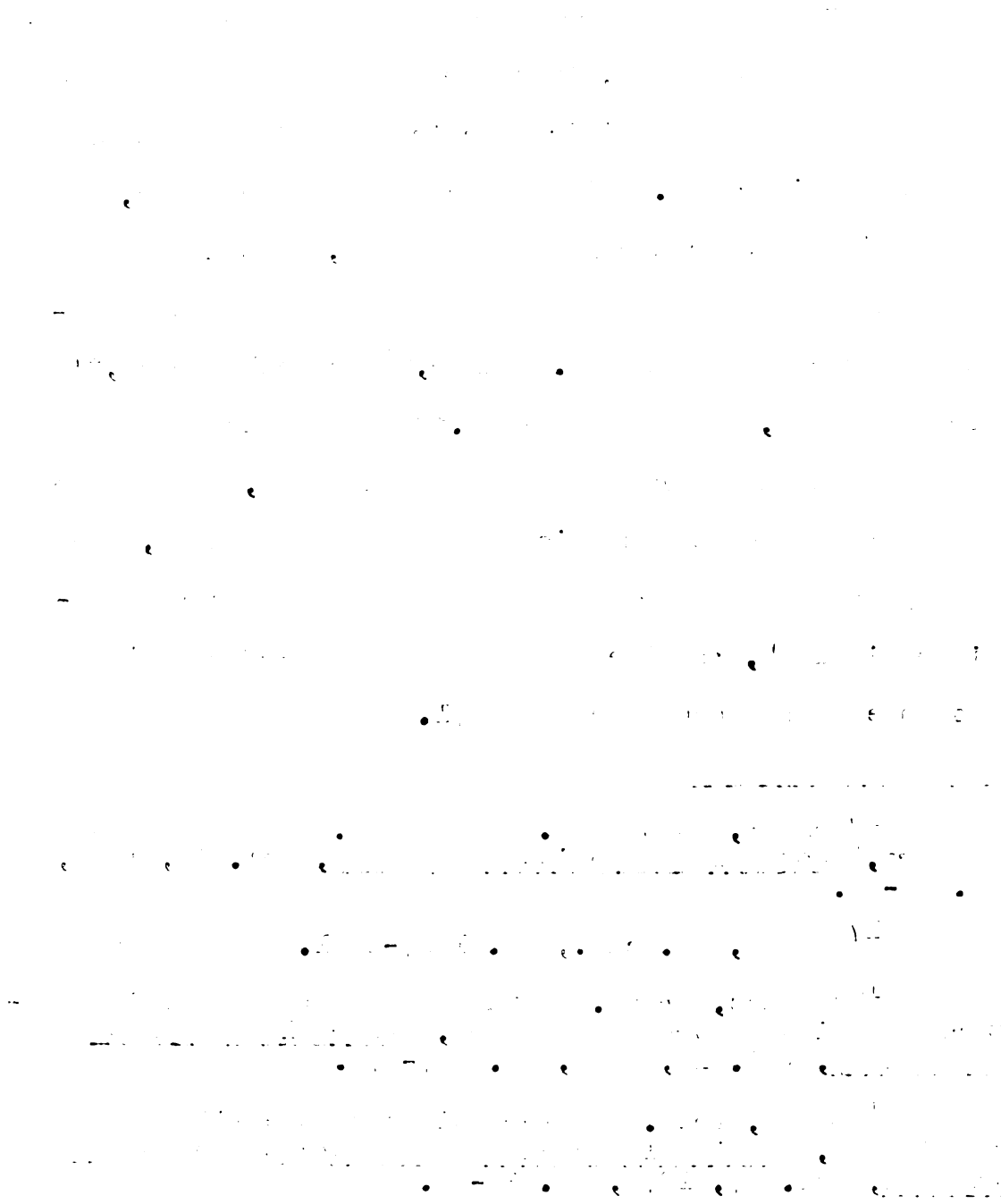
[16]Heller, Stanley S. and others. "Lung Volumes of Singers," Journal of Applied Physiology, Vol. 15, 1960, pp. 40-42.

[17]Berger, op. cit., pp. 1217-1221.

[18]Bouhuys, Arend. "Lung Volumes and Breathing Patterns in Wind Instrument Players," Journal of Applied Physiology, Vol. 19, 1964, pp. 967-975.

[19]Large, John. "Observations on the Vital Capacity of Singers," National Association of Teachers of Singing Journal, Vol. 27, 1971, pp. 34-35.



Heller Study

This study was designed to compare lung capacities of singers with those of non-singers. The vocal group consisted of nine female and seven male singers who were each engaged in professional singing or training. In the experimental group the seven male singers, with a mean age of 37.1 years, had training ranging from 1-37 years. The nine female singers had training ranging from 3-10 years and a mean age of 28.9 years. The control group consisted of 21 subjects with no previous vocal training or experience and had a mean age of 27.3 years for males and 26.6 years for females.

As a method of establishing predicted vital capacities of the subjects, Heller used the body surface area as a standard for measurement. He recorded the tidal volume, inspiratory capacity, inspiratory reserve volume, expiratory reserve volume, residual volume, maximum breathing capacity, functional residual capacity, and vital capacity of all the subjects involved in the testing.[20]

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[20] Tidal volume is the amount of air inhaled or exhaled during a normal breath. Inspiratory capacity is the volume of air that can be inhaled after normal expiration. Inspiratory reserve volume is the amount of air that can be inhaled following normal inhalation. Expiratory reserve volume is the amount of air that can be exhaled after normal expiration. Residual volume is the amount of air present in the lungs after maximal exhalation. Maximum breathing capacity is the volume of air that can be forced in and out of the lungs in one minute. Functional residual capacity is the volume of air in the lungs after normal exhalation.

The results indicated that both groups compared favorably with the accepted normal values. Although minor discrepancies existed, the author stated that they could be explained by age, body surface, or doubtful measurement. Heller concludes that in terms of the various divisions of lung volume no significant differences exist between professional singers and subjects who have had no professional vocal training. He suggests, however, that other respiratory tests examining the neural control of respiration might reveal some differences.[21]

Berger Study

This research measured the duration of tones, intraoral pressures, and rate of articulation of trumpet players performing in the high, middle, and low registers at both loud and soft dynamics. The experimental group consisted of ten male high school students who had performed on the cornet or trumpet for a minimum of four years prior to the study. Each subject was furnished with a Conn Victor trumpet on which his own mouthpiece was used.

Berger concluded that tones of high intensity, regardless of tonal frequency, require greater amounts of air than do tones of soft intensity. He noted that

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[21]Heller, op. cit., p. 42.

extreme frequencies require more air for soft tones, but found little difference for loud tones. A rank order listing of the subject's vital capacity, playing proficiency, and ability to sustain loud and soft tones was made. This study revealed that vital capacity was more of a determining factor for sustaining soft tones than playing proficiency, and that ability to sustain loud tones showed little correlation with either vital capacity or playing proficiency.

Intraoral pressure showed a direct correlation with tonal frequency and volume. Berger charted a step-like progression between the lower intraoral pressures required for lower frequencies and softer dynamic levels and the higher intraoral pressures required for higher frequencies and louder dynamic levels. His measurement of the rate of articulation showed little difference in regard to dynamic level.

Bouhuys Study

A measurement of lung capacities and breathing patterns of instrumentalists was the focal point of this study. In the experimental group, Bouhuys used 40 male and 2 female subjects who ranged in age from 18-70 years and had from 4-58 years of experience. Professional status ranged from conservatory students to performers in major orchestras, and a full complement of woodwind and brass instrumentalists was included in the test

group. Total lung volume and its subdivisions, acid-base balance, breathing patterns, mouth pressure, and air flow rate were measured in this research.

Bouhuys concluded that wind instrumentalists have larger vital capacities than the control subjects. He determined that this was true of subjects at all age levels and that brass players particularly have larger capacities. In measuring the acid-base balance, only minor changes were found in the blood after a half-hour of vigorous playing. Bouhuys noted that breathing patterns of most wind instrumentalists are similar with the exception of the oboists, who often exhale unused air at the ends of phrases before taking another breath. He found similarities in the charts of mouth pressures needed to play different frequencies on various instruments and found correlations in the flow rate of instruments in the brass family.

Large Study

This study measured the vital capacity of 20 male and 20 female vocalists, and compared their readings with predetermined amounts designated by Baldwin's formulae.[22] The subjects of this study were among a group

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[22]Baldwin, op. cit., pp. 243.

attending a vocal workshop at the University of Southern California. Their ages ranged from 22-75 years with a mean age of 44 years. Their singing experience ranged from 2-65 years with 28 years being the average. Male vocalists recorded increases of 16.1 percent and female vocalists recorded increases of 16.2 percent over predetermined norms. Large noted little correlation between the increase in vital capacity and number of years of singing experience.

Chapter 3

METHOD OF STUDY

The purpose of this research was to establish definitive measurements in terms of the vital capacity of the lungs in college age vocal and instrumental musicians. The selection of one parameter of respiratory measurement was done to make possible a fast testing procedure. This facilitated the collection of a large sampling of data to insure more accurate projections of the effects of wind instrument and vocal training on the musician's lung capacity. The study differs from the ones done by Heller, Bouhuys, and Large in that a much larger sampling of performers was used and stricter limitations were put on the experimental group. In addition, subjects were divided into categories according to the instrument they played and smokers were separated from non-smokers.

The Test

The study was performed during the months of March, April, and May in 1978. Students from the music departments of Western Michigan University, Central Michigan University, and Michigan State University made up the experimental group, with students from any departments of the same universities making up the control group.

In the lobbies or corridors of music departments of the previously mentioned schools, the researcher set up a table with a spirometer and solicited volunteers on a random basis.

Each student was asked to give his initials, age, height, weight, and instrument. He was then asked to answer questions related to his smoking habits, physical activities, general health, and practice habits. All students cooperated fully with the questioning; however, a few did not care to divulge their weight. Since weight was a less significant factor, its deletion did not adversely affect the study. After the information was recorded and while still in a standing position, the subjects inhaled fully and exhaled completely into the spirometer. This procedure was repeated three times and an average of these readings was used as a final comparison mark.

All people who expressed an interest in having their lung capacity measured were given the chance to have this done; however, only subjects who fit strict standards were used in this research. The subjects used in the experiment were expected to be a sophomore, junior, or senior enrolled full-time at an accredited university, between the ages of 18 and 23, in good health, and free of bronchial asthma, emphysema, or other respiratory disorders. Members of organized sports teams and those

who participated daily in rigorous fitness programs were not included in this study. It should be noted that judgement decisions had to be made by the researcher in regard to some of the students' outside physical activities. Subjects who participated in sports or fitness programs in a moderate way were used in both the control and experimental groups. This included students involved in intramural sports or similar activities, and students who maintained a fitness program for a period of less than 30 minutes no more than three times a week. Classification of the students with regard to their physical activities generally caused little problem.

The experimental group consisted of music majors seeking an undergraduate degree in music. These students were expected to have studied applied music at the universities they attended for a minimum of 1½ years consecutively, and be in good standing in their respective departments. Only instrumentalists who practiced or performed at least 14 hours a week and vocalists who practiced or performed at least 7 hours a week were used for this study. It should be noted that many students involved in this testing far exceeded the minimum performance requirements. Students who seriously studied two or more wind instruments and students with inconsistent practice habits were eliminated from the experimental group to make classification of data easier.

The control group consisted of both music majors and non-majors who had no previous training on a wind instrument or in voice. The exceptions to this were music majors who had studied various instruments in a classroom situation for a brief period of time as part of the requirements for a degree in music education. It was assumed that these students invested a minimal amount of time in learning the basic skills generally required of these classes, and therefore their physiology was not altered greatly by their brief encounters with these instruments.

All students tested were asked to give an accounting of their smoking habits. Students who at the time smoked and had smoked cigarettes or other tobacco substances daily for two years or more were classified as smokers. Students who had not smoked in two years and who never smoked daily for more than one year were classified as non-smokers. Although these categories are rigidly defined, the researcher was at times required to make judgements regarding classification. The primary considerations were whether one had ever smoked regularly for an extended period of time, and whether one had smoked regularly in the last few years. Almost every student tested easily fit into one of the categories; however, the few students who could not be placed into the smoking or non-smoking groups were

eliminated from the study for ease of classification of the data.

The following sheet was used for recording all data:

INITIALS _____ SEX _____ INSTRUMENT _____

AGE _____ HEIGHT _____ WEIGHT _____

(1) Do you smoke? (yes or no)

(2) Are you a sophomore, junior, or senior enrolled at this university? (yes or no)

(3) Have you studied applied music privately with an instructor at this university for 1½ consecutive years or more? (yes or no)

(4) If an instrumentalist, do you practice or perform 14 hours a week, or if a vocalist, do you practice or perform 7 hours a week? (yes or no)

(5) Do you have asthma, emphysema, or other disorders that might effect your vital capacity? (yes or no)

(6) Do you belong to any organized sports teams? (yes or no)

(7) Do you swim, jog, or do similiar exercises 4 times a week or more for a period exceeding 30 minutes? (yes or no)

Comments:

Test 1. _____ Average _____

Test 2. _____ Predicted Capacity _____

Test 3. _____ Percentage Difference _____

Information from the data sheets was transferred to charts which are listed in Appendix I.

Sample Testing Procedure

Three measurements of each student's vital capacity were taken and an average was computed. The student's average was compared with a predicted average determined in relation to the subject's height. The chart used for comparison is the one listed by Bass in his book describing lung function testing procedures.[23] This chart is listed in Appendix II.

Below are two sample measurements to be used in examining the testing procedure:

Sample Case 1

INITIALS A.A. SEX male INSTRUMENT clarinet
AGE 20 HEIGHT 5'11" WEIGHT 160 lbs.

Test 1. 4.8 Test 2. 5.0 Test 3. 4.9

Sample Case 2

INITIALS B.B. SEX female INSTRUMENT control
AGE 19 HEIGHT 5'4" WEIGHT 115 lbs.

Test 1. 2.9 Test 2. 3.0 Test 3. 3.0

Figure 1

Two Sample Cases

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[23]Bass, op. cit., pp. 86-87.

The averages were determined and this number was divided by the predicted capacity. The resulting figure indicated the percentage difference. It should be noted that all fractions of percentages were rounded off to the nearest number. The following figures show the mathematics involved in the sample cases:

Sample Case 1

Test 1. 4.8 liters
Test 2. 5.0
Test 3. 4.9

14.7 liters

$3\overline{)14.7}$ 4.9 liters

AVERAGE 4.9 liters

Sample Case 2

Test 1. 2.9 liters
Test 2. 3.0
Test 3. 3.0

8.9 liters

$3\overline{)8.9}$ 2.96 liters

AVERAGE 2.96 or 3.0 liters

Figure 2

Finding Averages

Sample Case 1

Predicted Capacity - 4.6 liters
Average - 4.9 liters

$$4.6\overline{)4.9} = 1.065$$

$$1.065 - 1.000 = .065 \text{ or } 6.5\%$$

PERCENTAGE DIFFERENCE 6.5% (or 7%)

Sample Case 2

Predicted Capacity - 3.2 liters
Average - 3.0 liters

$$3.2\overline{)3.0} = .937$$

$$1.000 - .937 = .063 \text{ or } 6.3\%$$

PERCENTAGE DIFFERENCE -6.3% (or -6%)

Figure 3

Finding Percentage Above and Below Predicted Amount

All data collected was treated as shown above and then placed into grouped categories based on instrument played. Below is a sample listing of grouped data:

	Sex	Age	Height	Weight	Test Average	Predicted Capacity	Percentage Difference	
(1)	M	20	5'6"	130	4.0	4.3	- 7%	*
(2)	M	19	5'9"	145	5.0	4.5	11%	
(3)	M	20	5'9"	154	4.4	4.4	0%	
(4)	M	22	5'8"	175	4.9	4.3	14%	
(5)	M	21	5'11"	170	4.9	4.6	7%	
(6)	M	19	6'0"	170	4.9	4.7	4%	*
(7)	M	21	5'11"	150	4.9	4.6	7%	*
(8)	M	21	6'2"	175	5.9	4.8	23%	
(9)	M	19	5'11"	148	4.5	4.6	- 2%	
(10)	M	21	5'6"	150	4.7	4.3	9%	
(11)	F	21	5'8"	130	4.0	3.4	18%	
(12)	F	22	5'4"	115	3.2	3.2	0%	
(13)	F	19	5'3"	116	3.4	3.2	6%	*
(14)	F	20	5'6"	115	3.2	3.3	- 3%	
(15)	F	20	5'6"	112	3.8	3.3	15%	*
(16)	F	20	5'8"	130	3.6	3.4	6%	
(17)	F	21	5'5"	115	3.3	3.2	3%	
(18)	F	21	5'8"	120	3.8	3.4	12%	
(19)	F	20	5'9"	130	3.3	3.5	- 6%	
(20)	F	19	5'3"	108	3.4	3.2	6%	

Figure 4

Sample List of Grouped Data

*** indicates smokers**

The above data was further divided into male-female and smoker-non-smoker subgroups and averages were determined. Below is a matrix for the data in Figure 4:

Table 1

Mean Percentages of Sample Group

	Males and Females	Males	Females
Total Group	6.2% (20)	6.6% (10)	5.7% (10)
Non-Smokers	6.5% (15)	8.9% (7)	4.5% (8)
Smokers	5.0% (5)	1.3% (3)	10.5% (2)

The matrix listed above indicates that the total group, smokers' group, and non-smokers' group have an average vital capacity greater than normal. It appears that there is little difference between the total group, smokers' group, and non-smokers' group, or between the males and females in the total group. Larger discrepancies can be noted when comparing the males and females in the smoking and non-smoking groups. These variances might be explained by the smaller sampling involved.

The percentiles used in the testing were at 10 percent intervals. In evaluating the sample data in Figure 4, 10 percent of the group were measured at the predicted capacity, 20 percent of the group had lung capacities smaller than predicted, 70 percent of the group had lung capacities of the predicted size or larger, 30 percent of the group had lung capacities more than 10 percent greater than predicted, and 5 percent of the group had lung capacities more than 20 percent greater

than predicted. The diagram below is a listing of the percentile readings of the sample group:

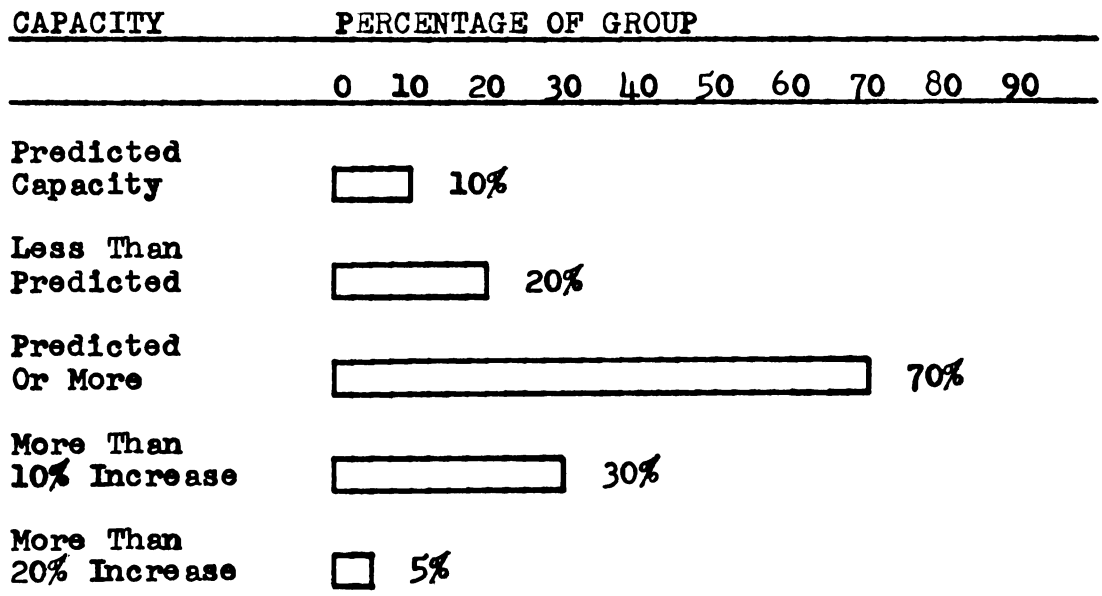


Figure 5

Percentile Readings of Sample Group

This testing procedure will help in comparing the modes of the various groups and subgroups being evaluated.

Chapter 4

ANALYSIS OF DATA

Although over 600 subjects were tested during the three month period when data was being accumulated, only 376 of them met the standards set up by the researcher for the experiment. In this group, 286 students were wind instrumentalists or vocalists and 90 students were non-instrumentalists or non-vocalists selected for the control group. Many similarities existed in comparison of the populations in the control and experimental groups. The control group had 24 percent smokers and 40 percent women and the instrumental/vocal group had 21 percent smokers and 43 percent women. Within the instrumental/vocal groups, however, the distributions were not as even. Whereas 87 percent of the flute players sampled were female, not one of the tuba players was female; and whereas 32 percent of the saxophonists were smokers, not one of the bassoonists smoked. The data shows, however, that more brass players sampled were male and more woodwind players and vocalists sampled were female, with the exception of the saxophonists. Each group also had approximately the same percentage of smokers with the control having 24 percent, the vocal

having 25 percent, the woodwinds having 22 percent, and the brass having 19 percent. Below is a chart that gives an overview of the data collected:

Table 2

Breakdown of Total Population

	Number of Subjects	Males	Females	Smokers
Control	90	60% (54)	40% (36)	24% (22)
Experimental	286	57% (162)	43% (124)	21% (61)
Vocal	73	42% (31)	58% (42)	25% (18)
Brass	112	79% (89)	21% (23)	19% (21)
Woodwind	101	42% (42)	58% (59)	22% (22)

The following table is an analysis of the brass and woodwind groups:

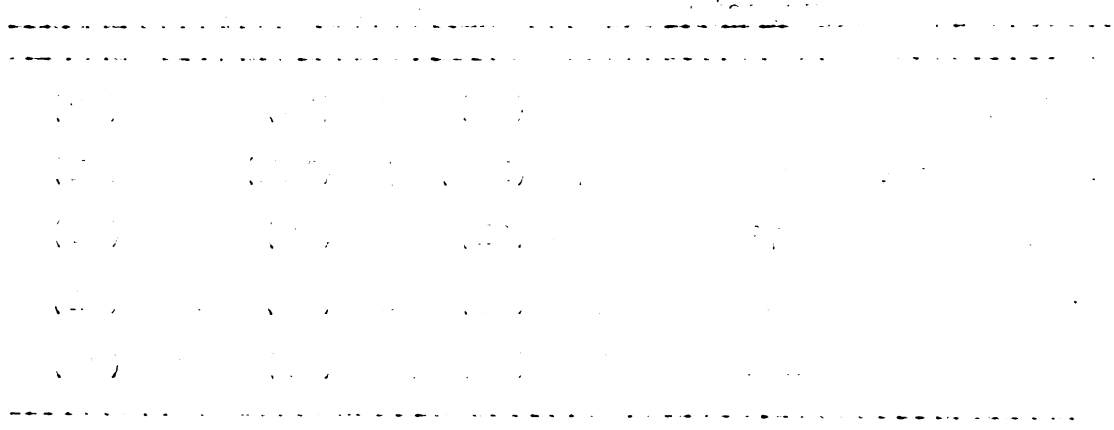


Table 3

Breakdown of Instrumentalists Tested

	Number of Subjects	Males	Females	Smokers
Trumpet	32	84% (27)	16% (5)	22% (7)
French Horn	27	52% (14)	48% (13)	22% (6)
Trombone	20	95% (19)	5% (1)	5% (1)
Euphonium	18	78% (14)	22% (4)	17% (3)
Tuba	15	100% (15)	0% (0)	27% (4)
Flute	24	13% (3)	87% (21)	17% (4)
Clarinet	33	45% (15)	55% (18)	30% (10)
Oboe	16	38% (6)	62% (10)	6% (1)
Bassoon	6	50% (3)	50% (3)	0% (0)
Sax	22	68% (15)	32% (7)	32% (7)

The Control Group

The 90 subjects in the control group had a range from 26 percent below to 32 percent above the predicted amount. The mean of the entire group, however, was .4 percent above the predetermined norm with the males having .3 percent less and the females having .4 percent more. Below is a matrix illustrating the averages for the control group:

Table 4

Mean Percentages of Control Group

	Males and Females	Males	Females
Total Group	.4% (90)	.1% (54)	.8% (36)
Non-Smokers	.6% (68)	.2% (41)	1.3% (27)
Smokers	- .4% (22)	- .3% (13)	- .6% (9)

The averages are almost all within fractions of a percentage point of zero indicating that the control group was measured at their predicted capacity.

The Experimental Group

The 286 members of the experimental group had a range from a 25 percent decrease to a 41 percent increase in capacity. The entire group had an average of 5.8 percent greater capacity than predicted, with the males having a 7.2 percent increase and the females having a 4.0 percent increase. The larger percentage in the males is due to the fact that more of them were represented in the brass group, which showed greater increases.

The smokers in the experimental group had a 5.3 percent increase in capacity; however, this is only slightly less than the 6.0 percent figure of the non-smokers. Greater differences can be found when comparing the female smoking group with the non-smoking group, although the variance translates to less than

one tenth of a liter decrease in the average female vital capacity. Below is a table listing the data for the entire experimental group:

Table 5

Mean Percentages of Experimental Group

	Males and Females	Males	Females
Total Group	5.8% (286)	7.2% (162)	4.0% (124)
Non-Smokers	6.0% (225)	7.4% (123)	4.3% (102)
Smokers	5.3% (61)	6.7% (39)	2.1% (22)

All data in the above graph indicates that the measurements of lung capacities in the experimental group are greater than those of the control group.

The Vocal Group

The 73 subjects in the vocal group, who make up the largest individual group in this study, had a range from 21 percent below to 32 percent above the predetermined norm. The average capacity for the group was 4.0 percent greater than predicted, and the males had slightly smaller increases than the females. The vocalists who smoked had 2.2 percent smaller capacities than the non-smoking group, with the largest difference occurring among the females tested. Below is a matrix illustrating their averages:

Table 6

Mean Percentages of Vocal Group

	Males and Females	Males	Females
Total Group	4.0% (73)	3.6% (31)	4.2% (42)
Non-Smokers	4.5% (55)	3.8% (22)	5.0% (33)
Smokers	2.3% (18)	3.0% (9)	1.6% (9)

Although lower than the averages of the entire experimental group, the vocalists show slightly larger increases than the members of the control group.

The Brass Instrument Group

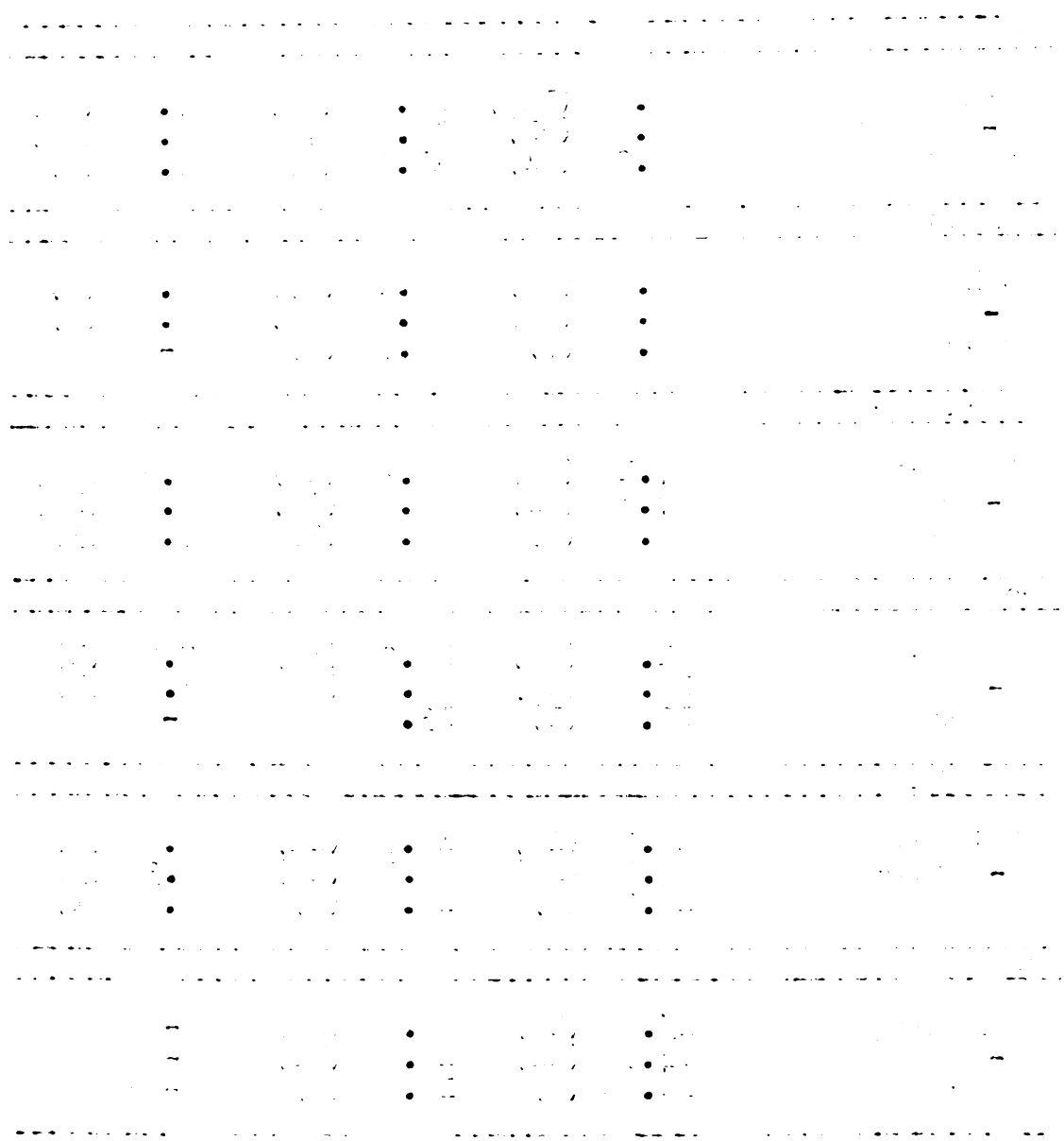
The brass instrument group consisted of students who play the trumpet, French horn, trombone, euphonium, and tuba. This was the largest family of instruments tested and the individual capacities were larger than those of the other groups measured. The total group of brass players had a range from 16 percent below the predicted amount to 38 percent above the predicted amount. The mean for this group was 9.9 percent greater than predicted, with the males having larger increases than the females. Smokers in the brass instrument group were measured with slightly larger capacities than non-smokers; however, the differences are fractions of a percentage point which indicates that the variances are minimal. Low brass instrumentalists showed the largest increases

with the tubaists being measured at 15.4 percent above, the trombonists being measured at 11.0 percent above, and the euphonium players being measured at 10.3 percent above. The trumpet and French horn players recorded slightly lower readings with the trumpet group being measured at 8.7 percent above and the French horn group being measured at 7.1 percent above. The following table lists the mean percentages of the brass players:

Table 7

Mean Percentages of Brass Group

	Males and Females	Males	Females
Brass Instrument Group			
Total Group	9.9% (112)	10.5% (89)	7.4% (23)
Non-Smokers	9.8% (91)	10.4% (72)	7.4% (19)
Smokers	10.3% (21)	11.1% (17)	7.5% (4)
Trumpet			
Total Group	8.7% (32)	9.1% (27)	6.6% (5)
Non-Smokers	8.4% (25)	8.9% (20)	6.6% (5)
Smokers	9.7% (7)	9.7% (7)	-
French Horn			
Total Group	7.1% (27)	8.2% (14)	5.9% (13)
Non-Smokers	7.6% (21)	9.4% (11)	5.6% (10)
Smokers	5.5% (6)	4.0% (3)	7.0% (3)
Trombone			
Total Group	11.0% (20)	10.2% (19)	27.0% (1)
Non-Smokers	10.9% (19)	10.0% (18)	27.0% (1)
Smokers	13.0% (1)	13.0% (1)	-
Euphonium			
Total Group	10.3% (18)	10.9% (14)	8.5% (4)
Non-Smokers	9.9% (15)	10.3% (12)	8.3% (3)
Smokers	12.3% (3)	14.0% (2)	9.0% (1)
Tuba			
Total Group	15.4% (15)	15.4% (15)	-
Non-Smokers	14.9% (11)	14.9% (11)	-
Smokers	16.8% (4)	16.8% (4)	-



In observing the data for the individual brass instrument groups in Table 7, it is interesting to note the 27 percent increase in capacity recorded by the female trombonist. This reading translates to an increased capacity of almost one liter over predicted amounts; however, it is hard to draw meaningful conclusions based on the data of one subject.

The Woodwind Instrument Group

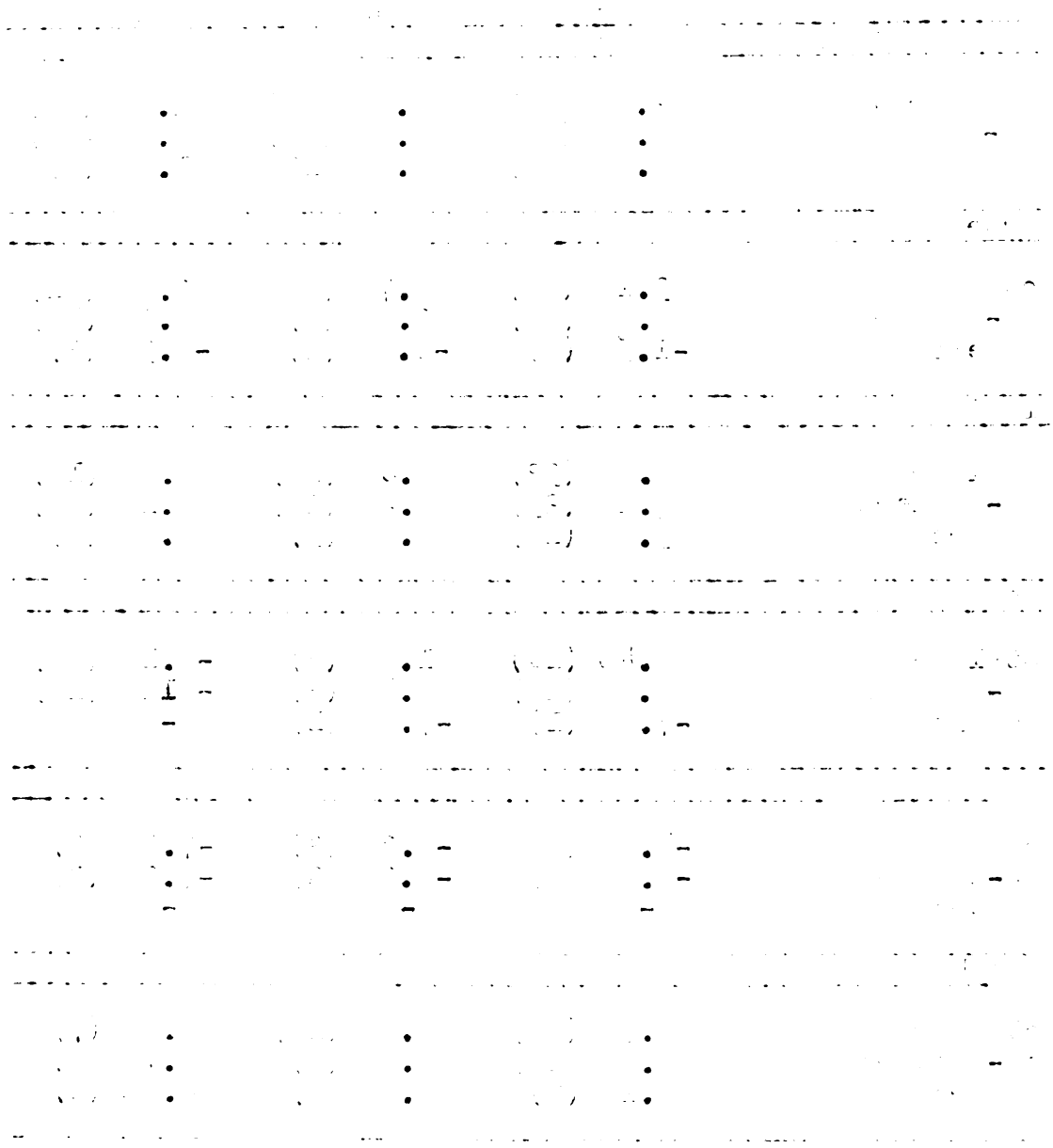
The woodwind instrument group, which consisted of students who play the flute, clarinet, oboe, bassoon, and saxophone, was the second largest family of instruments tested. The woodwind players, however, had the smallest overall increase in capacity in comparison to the vocal and brass groups. The total woodwind group had a range from 24 percent below the expected amount to 41 percent above the expected amount, with 2.6 percent above being the mean. In this group, there is little difference in comparing males with females and smokers with non-smokers, indicating that all groups measured show little variance in relation to the total group. The single reed players recorded the largest increases with the clarinetists being measured at 4.0 percent above and the saxophonists being measured at 3.7 percent above. Flute players registered an average increase of 3.1 percent over the predetermined norm. The double

reed players, however, registered the lowest readings with the oboists having a mean of .4 percent above and the bassoonists having a mean of 4.8 percent below. The following table lists the mean percentages of data collected in the woodwind group:

Table 8

Mean Percentages of Woodwind Group

	Males and Females	Males	Females
Woodwind Instrument Group			
Total Group	2.6% (101)	2.8% (42)	2.5% (59)
Non-Smokers	2.7% (79)	2.8% (29)	2.6% (50)
Smokers	2.5% (22)	2.9% (13)	1.8% (9)
Flute			
Total Group	3.1% (24)	.7% (3)	3.5% (21)
Non-Smokers	4.0% (20)	3.5% (2)	4.1% (18)
Smokers	-1.5% (4)	-5.0% (1)	- .3% (3)
Clarinet			
Total Group	4.0% (33)	4.6% (15)	3.6% (18)
Non-Smokers	4.1% (23)	4.2% (10)	4.1% (13)
Smokers	3.8% (10)	5.4% (5)	2.2% (5)
Oboe			
Total Group	.4% (16)	1.2% (6)	- .1% (10)
Non-Smokers	.9% (15)	2.8% (5)	- .1% (10)
Smokers	-7.0% (1)	-7.0% (1)	-
Bassoon			
Total Group	-4.8% (6)	-2.3% (3)	-7.3% (3)
Non-Smokers	-4.8% (6)	-2.3% (3)	-7.3% (3)
Smokers	-	-	-
Saxophone			
Total Group	3.7% (22)	3.2% (15)	4.9% (7)
Non-Smokers	3.5% (15)	2.8% (9)	4.7% (6)
Smokers	4.1% (7)	3.8% (6)	6.0% (1)



The bassoonists were the only group to record averages below predicted amounts. Because of the small sampling and skewed data involved in this group's readings, the median (which is -1.5 percent) will be used instead of the mean to compare the bassoon player's data with other groups. This should give a more accurate evaluation of their capacities.

Males Compared With Females

In observing the matrixes in Tables 6, 7, and 8, one immediately sees that male trumpet, French horn, euphonium, clarinet, and oboe players have greater increases than females who play the same instruments. Likewise, female vocal, trombone, flute, and saxophone players have greater increases than males who play the same instruments. This can be misleading, however, because often the grouped data arranged by sex contains very small samplings. Such is the case with the female trombonists and male flutists. If all the data is pooled and variations are averaged, one sees that the average deviation from the total group is .6 percent for males and .7 percent for females. Although the percentages of variance are near equal, the average male still has approximately one liter more of air than the typical female of the same height. This seems to indicate that although females start with smaller capacities, their physiology does not change more drastically to compensate for the

difference. Therefore, it appears that males and females are effected equally by vocal or wind instrument performance.

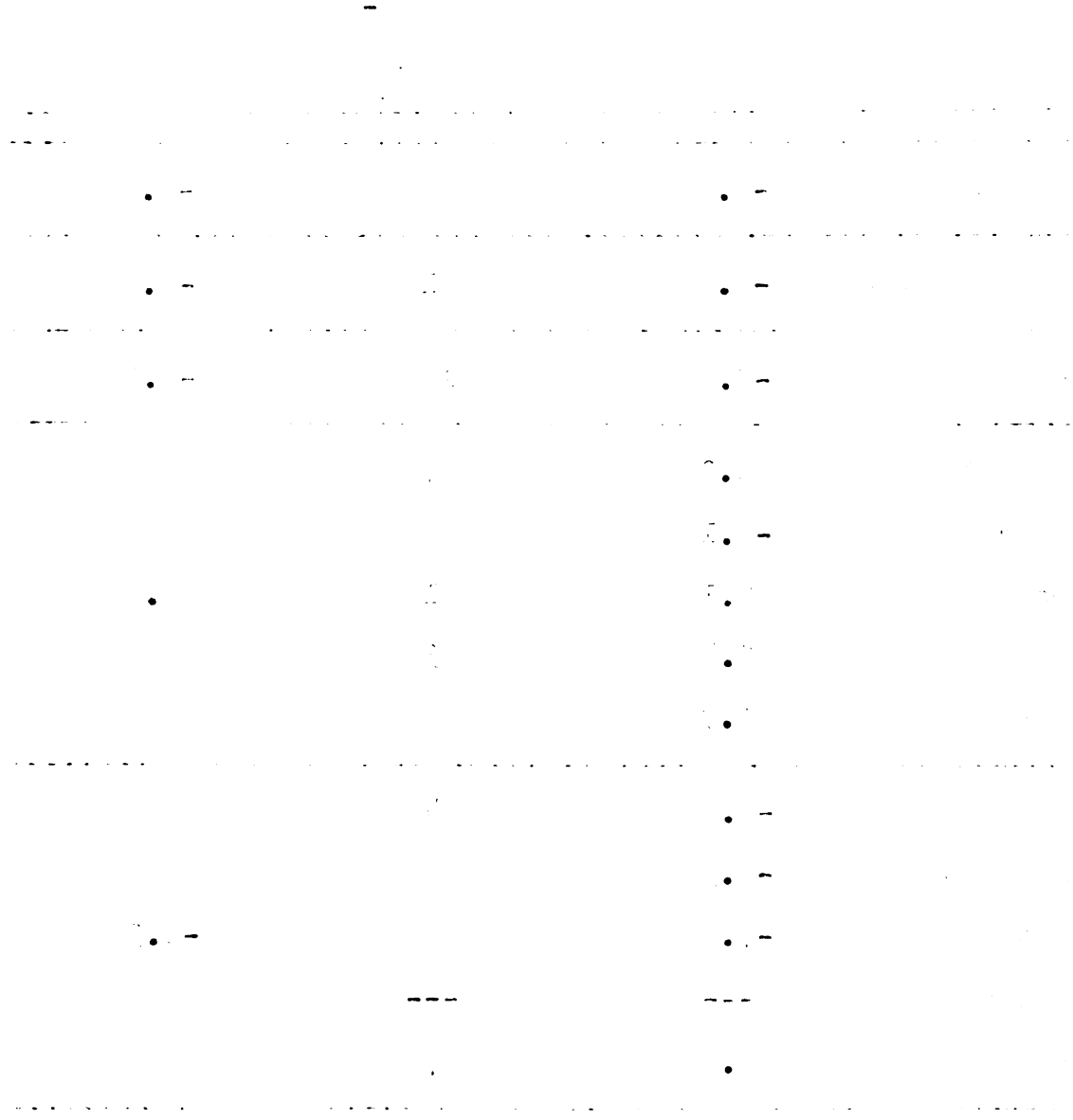
Smokers Compared With Non-Smokers

Sixty-one smokers were registered in the experimental group, and 22 smokers were registered in the control group. Of the three divisions in the experimental group, the vocalists seemed to be most affected by smoking, with mean capacities 2.2 percent lower than non-smokers in that group. The brass instrument players seemed to be less affected by smoking having a .6 percent average increase over the brass players who did not smoke. The woodwind players, who showed the most variation among members of the family, had a 1.3 percent decrease when compared with non-smoking woodwind players. Below is a table listing the data:

Table 9

Comparison of Smokers with Non-Smokers

	Average Difference	Number of Smokers	Average by Family
Control	-1.0%	22	-1.0%
Experimental	- .9%	61	- .9%
Vocal	-2.2%	18	-2.2%
Trumpet	1.3%	7	
French Horn	-2.1%	6	
Trombone	2.1%	1	.6%
Euphonium	2.4%	3	
Tuba	1.9%	4	
Flute	-5.5%	4	
Clarinet	- .3%	10	
Oboe	-7.0%	1	-1.3%
Bassoon	---	---	
Saxophone	.6%	7	



The entire instrumental/vocal group of smokers had an average capacity .9 percent below non-smokers, which is .1 percent above the 1.0 percent decrease registered by the smokers in the control group. The -.9 percent and -1.0 percent averages indicate a decrease of less than one tenth of a liter for the typical male or female. Therefore, smoking seems to have only a slight effect on the vital capacity of college age students.

Increases By Percentile

Percentile charts were used to examine the data collected in an alternate manner. Figures 6, 7, and 8 list the percentage of capacities greater than expected, greater than 10 percent, and greater than 20 percent. In all three figures, members of the experimental group, with the exception of bassoonists, show percentages equal or greater than the control group. Below is a listing of the three percentile charts:

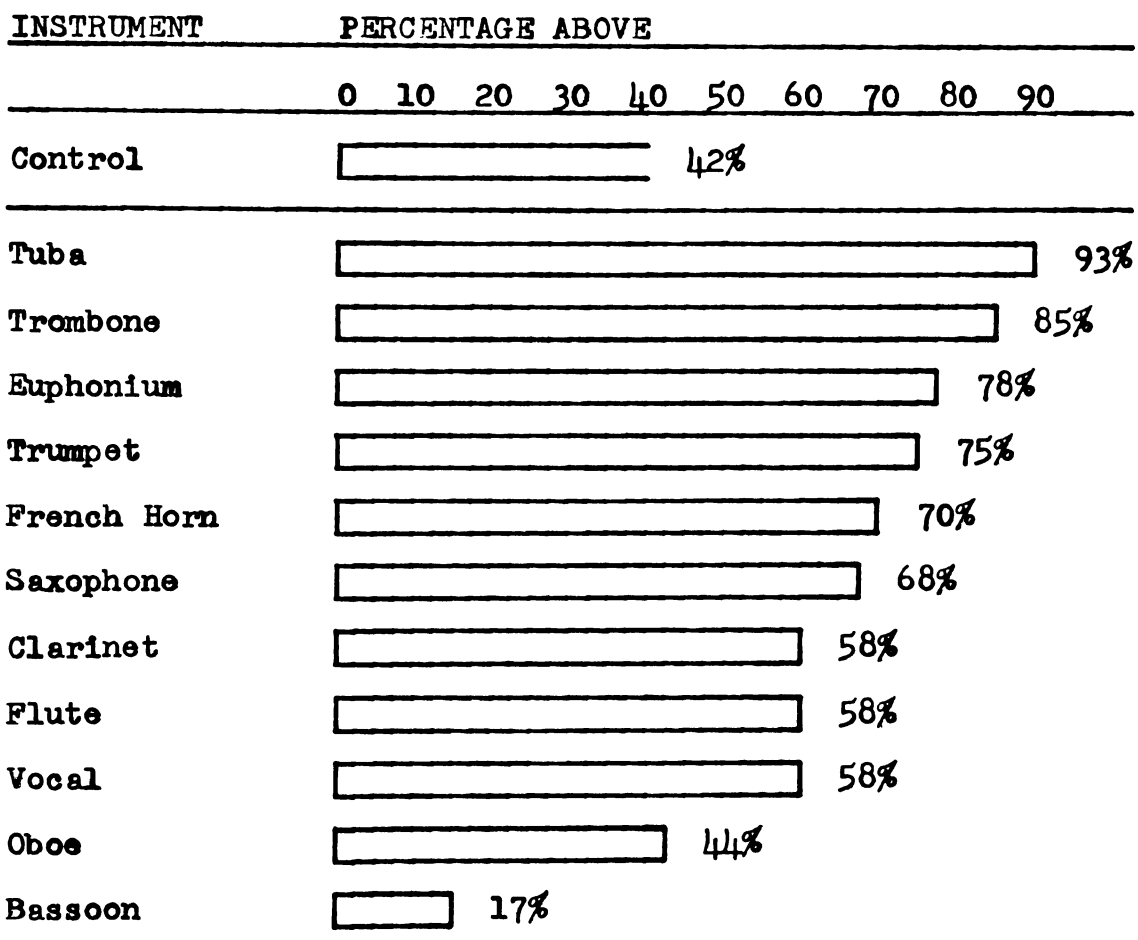
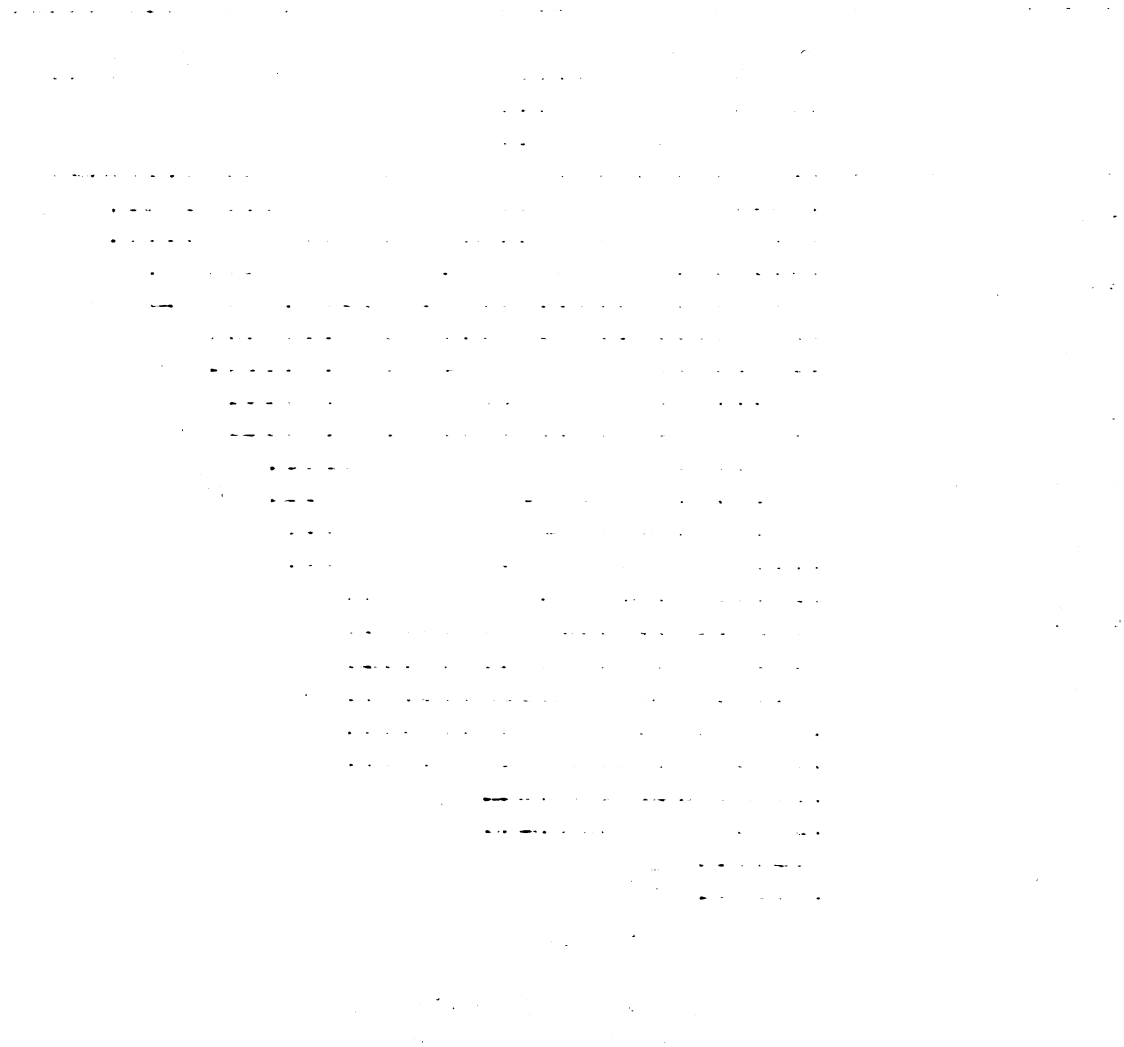


Figure 6

Percentage of Capacities
Larger than Expected



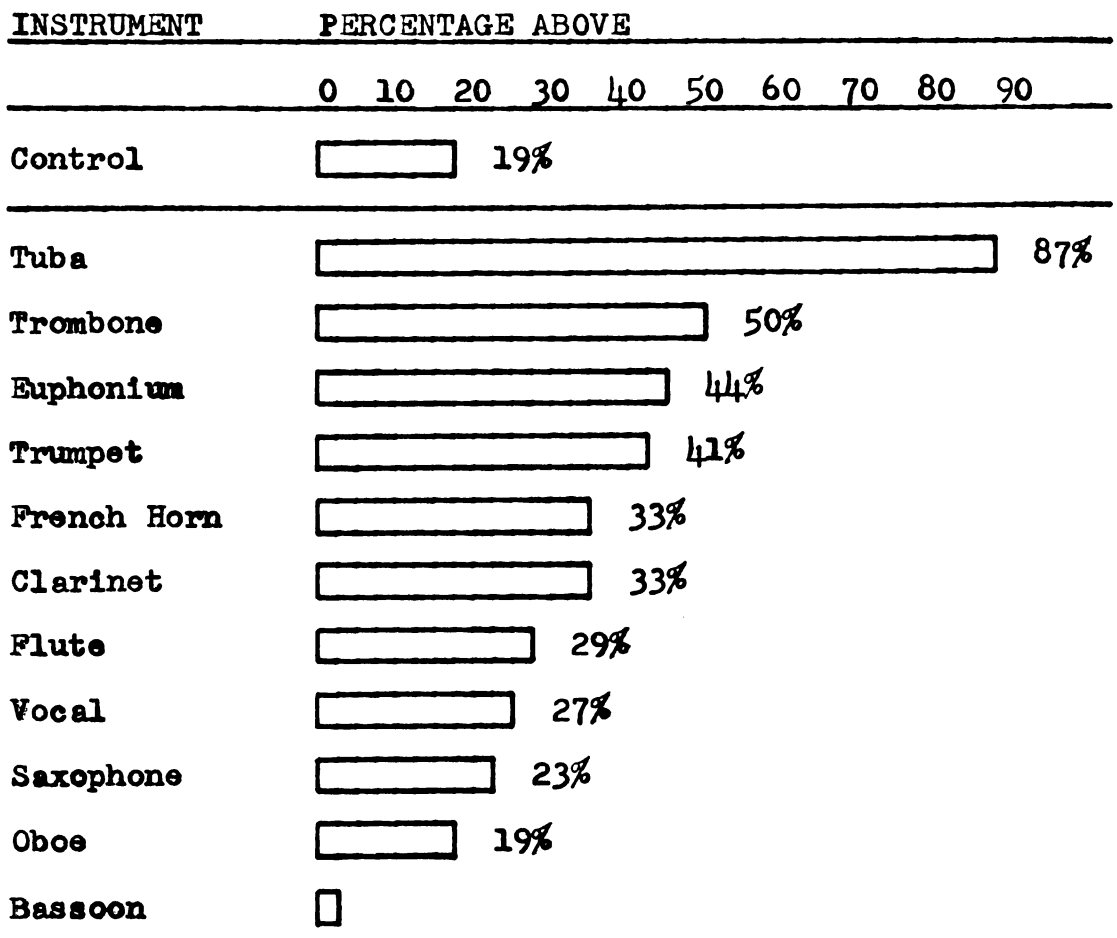


Figure 7

Percentage of Capacities
Greater than 10%

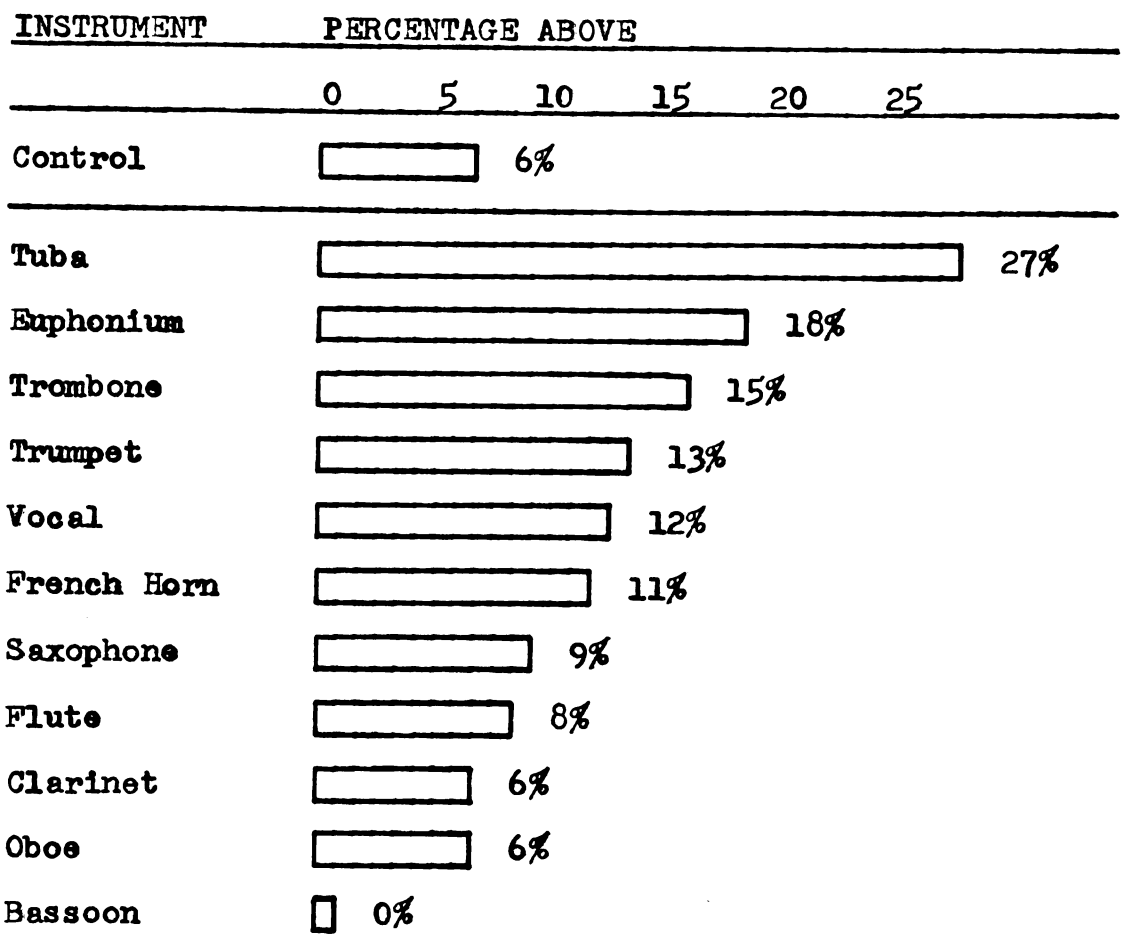


Figure 8

Percentage of Capacities
Greater than 20%

The rank ordering of percentages in Figures 6, 7, and 8 indicate that in all the levels greater than predicted, the brass players show larger increases than the vocalists or woodwind players. Low brass instrument players are consistently in the top three positions, with the tubaists always registering the highest percentage. Vocalists and woodwind players are almost always in the bottom six positions, with the oboe and bassoon players consistently showing the smallest percentages.

Chapter 5

SUMMARY AND CONCLUSIONS

Summary

The vital capacity of 286 instrumentalists and vocalists was measured and compared with the vital capacity of 90 subjects with no wind instrument or vocal training. The experimental group consisted of college students seeking an undergraduate degree in music who had studied applied music at the college level for a minimum of 1½ consecutive years. Information about each subject's age, height, weight, sex, smoking habits, physical activities, and practice routines was recorded, and then the subject's vital capacity was measured. This measurement was compared to a predicted capacity based on one's sex and height, and the percentage difference was registered.

The data that was accumulated was directed toward the following questions:

1) Is there a difference in vital capacity when comparing the wind instrumental/vocal musician with non-performers?

2) Do capacities vary between performers of different instruments?

3) Is there a variation in lung capacities of

men and women who play the same instrument?

4) Does smoking have an effect on a performer's vital capacity?

Conclusions

The data collected suggest the following conclusions:

1) The vital capacities of the wind instrumentalists and vocalists generally appear to be larger than those of the control subjects.

2) Brass instrumentalists seem to register higher increases than members of either the vocal or woodwind groups.

3) The female vital capacity does not change more drastically to compensate for the initial difference between men's and women's lung volumes. Therefore, it seems that men and women are effected equally by wind instrument or vocal performance.

4) Smokers appear to have only slightly smaller vital capacities than non-smokers.

Discussion

The data, as it was presented, seem to imply that instrumental performance caused the experimental group to develop larger capacities. It should be noted, however, that although the average heights in both the control and experimental groups were within one inch of each other,

the average weights of the members of these groups showed more diversity. Among the males, the average weight of the subjects in the experimental group was 13 pounds more than the weight of the subjects in the control group. In the male instrumental/vocal group, low brass players weighed six pounds above the norm and woodwind players weighed six pounds below the norm. Among the females, the average weight for subjects in the experimental group was only three pounds greater than the weight of the subjects in the control group. Female brass players, however, weighed nine pounds more than female woodwind players. The larger increases in the weight of subjects in the experimental group might help explain their increased capacities. This particularly could apply to the brass players. A study by Kory, however, indicated that weight is the least accurate factor in predicting lung volumes.[24]

Smokers in this study registered only minor decreases over non-smokers. It should be noted that although all subjects in the smoking category indicated that they smoked regularly, many stated that this was not done excessively. Studies involving frequency and type of substance smoked might reveal more startling differences.

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[24]Kory, op. cit., pp. 243-258.

The author was familiar with the performance abilities of some subjects in this study. Although some might assume that correlations exist between one's ability to sing or perform on a wind instrument and the size of one's lungs, the researcher noted instances in which excellent performers were measured with small capacities. Conclusions relating ability and lung volume, however, were not a part of this study.

Recommendations For Further Study

Studies might be created to measure the vital capacities of musicians in different age groups and test other parameters of lung measurement. Although this study involved college students who generally have a moderate degree of proficiency on their instruments, it might be of more significance to study professional musicians who make a career of performing. A study of this nature could take a sampling of professional musicians' vital capacities and then divide the data into different groups designated by age, instrument, sex, and smoking habits. Considering that most of the musicians tested would be much older than those used in this study, a project like this could measure the long term effects of wind instrument and vocal performance on the lungs and would more accurately evaluate the long term effects of smoking on the wind instrument and vocal musician. The problem involved with a study of this

nature is acquiring a large enough experimental group to make the research meaningful.

A more feasible project would be to apply this study to young instrumentalists. A research project could be designed in which beginning instrumentalists' and vocalists' vital capacities are measured, and then remeasured at a later time to see if instrumental or vocal performance changes them. Another study could be created to chart the progress of young students against the size of their vital capacities to see if correlations exist between a student's success on wind instruments or in voice and the size of his lungs. Tests of this nature, however, would be most effective if performed over an extended period of time.

Although only the vital capacities of subjects were compared in this study, numerous other lung function tests could be designed. Tests measuring other divisions of lung volumes, studies registering vital capacity measurements as a timed maneuver, and experiments measuring control in the respiratory process might reveal more striking differences between the musician and non-musician.

The scientific study of instrumental and vocal performers is long overdue. Many of our present treatises on instrumental and vocal techniques are based on ideas that have been passed down for generations, but never really tested in any experimental situation. In spite of our advanced knowledge of physiology and instrument design,

there is little difference in performance manuals written today and those written decades ago. We, as performers, need to do more objective testing so that accurate facts can be established in order to more effectively teach the skills of musical performance.

APPENDIX

Appendix I

COMPLETE LISTING OF ALL DATA

CONTROL GROUP

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	23	5'11"	165	5.3	5.3	5.2	5.3	4.5	18%
2)	M	22	6'0"	195	5.1	5.4	5.3	5.3	4.6	15% *
3)	M	20	5'6"	130	4.1	4.0	3.8	4.0	4.3	- 7%
4)	M	23	6'1"	215	4.5	4.4	4.6	4.5	4.7	- 4%
5)	M	19	5'9"	145	5.0	5.1	5.0	5.0	4.5	11%
6)	M	22	5'4"	132	3.4	3.6	3.7	3.6	4.1	-12%
7)	M	20	5'8"	130	4.1	4.2	4.2	4.2	4.4	- 5%
8)	M	20	6'0"	165	4.5	4.7	4.6	4.6	4.6	0%
9)	M	22	5'8"	175	4.8	4.8	4.8	4.8	4.3	12%
10)	M	19	5'10"	170	4.3	4.0	4.0	4.1	4.5	- 9%
11)	M	20	5'9"	145	4.5	4.4	4.4	4.4	4.4	0% *
12)	M	18	5'7"	130	4.1	4.0	4.0	4.0	4.4	- 9%
13)	M	20	5'8"	160	3.8	4.2	4.2	4.1	4.4	- 7%
14)	M	21	5'7"	142	3.6	3.7	3.8	3.7	4.3	-14% *
15)	M	20	6'2"	170	4.5	4.4	4.5	4.5	4.8	- 6%
16)	M	21	6'1"	170	6.1	6.1	6.1	6.1	4.7	30%
17)	M	21	5'10"	180	4.1	4.7	4.7	4.5	4.5	0%
18)	M	22	5'6"	125	4.0	4.0	3.9	4.0	4.2	- 5% *
19)	M	19	5'4"	145	3.7	4.0	4.0	3.9	4.2	- 7% *
20)	M	20	5'10"	180	4.4	4.5	4.6	4.5	4.5	0%
21)	M	20	5'9"	140	4.4	4.3	4.2	4.3	4.4	- 2%
22)	M	22	5'8"	155	4.4	4.4	4.5	4.4	4.3	2% *
23)	M	20	5'9"	160	4.6	4.7	4.5	4.6	4.4	5% *
24)	M	22	5'11"	155	3.5	3.8	4.0	3.8	4.5	-16%
25)	M	20	5'5"	160	3.8	3.8	3.8	3.8	4.2	-10%
26)	M	21	5'5"	140	3.1	4.1	4.1	3.8	4.2	-10%

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
27)	M	20	5'9"	155	3.4	3.5	3.6	3.5	4.4	-20%
28)	M	19	6'0"	170	4.9	5.0	4.9	4.9	4.7	4% *
29)	M	19	6'2"	175	5.0	4.8	4.9	4.9	4.8	2%
30)	M	19	6'0"	220	3.3	3.5	3.7	3.5	4.7	-26%
31)	M	19	5'11"	148	4.5	4.5	4.5	4.5	4.6	- 2%
32)	M	22	5'11"	155	4.7	5.0	4.8	4.8	4.5	7%
33)	M	20	5'7"	150	4.5	4.7	4.8	4.7	4.3	9% *
34)	M	19	6'0"	170	4.4	4.5	4.6	4.5	4.7	- 4%
35)	M	20	6'2"	180	4.4	4.5	4.5	4.5	4.8	- 6%
36)	M	20	5'6"	150	3.4	3.2	3.4	3.3	4.3	-23%
37)	M	21	5'11"	170	4.9	5.0	4.8	4.9	4.6	7% *
38)	M	19	6'3"	165	5.7	5.6	5.8	5.7	4.8	19%
39)	M	21	5'6"	140	4.4	4.4	4.5	4.4	4.3	2%
40)	M	19	6'3"	150	4.9	4.7	4.9	4.8	4.8	0% *
41)	M	21	5'6"	128	4.9	4.5	4.8	4.7	4.3	9%
42)	M	22	5'11"	160	5.1	4.9	4.9	5.0	4.5	11%
43)	M	19	6'0"	205	6.2	6.2	6.1	6.2	4.7	32%
44)	M	19	5'11"	155	4.6	4.5	4.8	4.6	4.6	0%
45)	M	20	5'5"	130	4.0	4.0	4.1	4.0	4.2	- 5% *
46)	M	20	5'6"	125	3.3	3.2	3.5	3.3	4.3	-23%
47)	M	20	6'2"	195	5.2	5.4	5.4	5.3	4.8	10%
48)	M	19	5'7"	150	3.7	3.9	3.8	3.8	4.3	-12%
49)	M	21	5'8"	175	4.5	4.4	4.4	4.4	4.4	0%
50)	M	18	5'11"	160	4.0	3.9	3.9	3.9	4.6	-15% *
51)	M	20	5'11"	160	5.1	5.2	5.3	5.2	4.6	13%
52)	M	19	6'3"	165	5.4	6.0	6.0	5.8	4.8	21%
53)	M	21	6'2"	175	5.9	5.9	6.0	5.9	4.8	23%
54)	M	21	5'7"	140	4.2	4.3	4.6	4.4	4.3	2%

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
55)	F	21	5'8"	130	4.0	4.1	4.0	4.0	3.4	18%
56)	F	19	5'9"	135	2.8	2.8	2.7	2.8	3.5	-20%
57)	F	19	5'6"	135	3.0	2.9	3.0	3.0	3.3	- 9%
58)	F	22	5'4"	115	3.2	3.2	3.3	3.2	3.2	0%
59)	F	20	5'2"	125	3.1	2.7	3.4	3.1	3.1	0%
60)	F	20	5'5"	125	3.7	3.9	3.8	3.8	3.3	15% *
61)	F	21	5'6"	125	3.7	3.4	3.7	3.6	3.4	6% *
62)	F	19	5'4"	120	3.1	3.6	3.4	3.4	3.2	6%
63)	F	20	5'9"	130	3.3	3.3	3.3	3.3	3.5	- 6%
64)	F	19	5'3"	116	3.5	3.4	3.3	3.4	3.2	6%
65)	F	20	5'6"	115	3.2	3.1	3.2	3.2	3.3	- 3%
66)	F	20	5'6"	125	3.7	3.7	3.8	3.7	3.3	12%
67)	F	21	5'5"	130	3.8	4.0	4.0	3.9	3.3	18%
68)	F	23	5'7"	130	3.5	3.1	3.0	3.2	3.3	- 3%
69)	F	19	5'4"	130	3.3	3.4	3.3	3.3	3.2	3% *
70)	F	21	5'6"	120	3.1	2.9	2.8	3.0	3.3	- 9% *
71)	F	22	5'3"	127	3.2	3.1	3.0	3.1	3.1	0%
72)	F	21	5'0"	95	2.2	2.6	2.6	2.5	3.0	-17% *
73)	F	20	5'8"	130	3.5	3.5	3.9	3.6	3.4	6%
74)	F	19	5'7"	?	3.8	3.9	4.0	3.9	3.4	15%
75)	F	19	5'4"	125	3.1	3.1	3.1	3.1	3.2	- 3%
76)	F	19	5'2"	125	2.6	2.7	2.8	2.7	3.1	-13%
77)	F	19	5'5"	140	3.2	3.3	3.5	3.3	3.3	0%
78)	F	21	5'5"	134	3.4	3.3	3.3	3.3	3.2	3%
79)	F	22	5'7"	125	3.0	3.0	3.1	3.0	3.3	- 9% *
80)	F	19	5'8"	130	3.5	3.3	3.7	3.5	3.4	3%
81)	F	20	5'7"	130	3.1	3.2	3.3	3.2	3.4	- 6%
82)	F	19	5'4"	110	3.2	3.1	3.2	3.2	3.2	0%

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
83)	F	21	5'6"	118	3.2	3.2	3.2	3.2	3.3	- 3%
84)	F	20	5'7"	116	3.5	3.5	3.5	3.5	3.4	3% *
85)	F	21	5'8"	125	3.6	3.7	3.7	3.7	3.4	9% *
86)	F	20	5'4"	120	3.1	3.2	3.1	3.1	3.2	- 3%
87)	F	20	5'6"	126	2.4	2.7	2.6	2.6	3.3	-21%
88)	F	23	5'8"	130	4.4	4.4	4.4	4.4	3.4	29%
89)	F	19	5'5"	120	3.2	3.1	3.1	3.1	3.3	- 6% *
90)	F	21	5'6"	125	3.7	3.6	3.5	3.6	3.3	9%

VOCALISTS

	Sex	Age	Height	Weight	(1)	(2)	(3)	Average	Predicted Capacity	Difference	
1)	M	20	5'10"	170	5.2	4.6	4.8	4.9	4.5	9%	
2)	M	22	5'6"	165	4.8	4.8	4.8	4.8	4.2	14%	
3)	M	22	5'11"	160	4.6	4.7	4.7	4.7	4.5	4%	*
4)	M	22	5'10"	160	4.1	4.3	4.4	4.3	4.5	- 4%	
5)	M	20	5'2"	130	4.1	4.2	4.3	4.2	4.0	5%	*
6)	M	21	6'1"	195	4.9	4.9	4.8	4.9	4.7	4%	*
7)	M	22	6'0"	165	3.8	4.0	4.0	3.9	4.6	-15%	
8)	M	21	6'0"	165	4.2	5.0	5.0	4.7	4.6	2%	
9)	M	19	6'2"	175	5.3	5.1	5.2	5.2	4.8	8%	
10)	M	19	5'11"	230	4.4	4.4	4.5	4.4	4.6	- 4%	
11)	M	20	5'10"	140	4.9	4.8	4.9	4.9	4.5	9%	
12)	M	20	5'7"	170	4.5	4.0	4.5	4.3	4.3	0%	*
13)	M	21	5'8"	135	3.8	4.0	4.1	4.0	4.4	- 9%	*
14)	M	20	6'1"	220	6.0	6.1	6.1	6.1	4.7	30%	
15)	M	21	6'1"	155	4.6	4.5	4.6	4.6	4.7	- 2%	*
16)	M	20	5'7"	160	5.3	5.4	5.6	5.4	4.3	26%	*
17)	M	21	5'10"	140	4.3	4.2	4.2	4.2	4.5	- 7%	
18)	M	19	5'11"	160	3.9	3.6	4.4	4.0	4.6	-13%	
19)	M	19	6'2"	160	4.9	5.0	4.9	4.9	4.8	2%	
20)	M	19	6'0"	160	5.1	5.1	5.2	5.1	4.7	9%	*
21)	M	20	6'0"	215	4.5	4.2	4.2	4.3	4.6	- 7%	
22)	M	21	6'3"	250	4.0	5.3	5.5	4.9	4.8	2%	
23)	M	22	6'2"	180	4.7	4.7	4.8	4.7	4.7	0%	
24)	M	20	5'11"	150	4.1	4.2	4.3	4.2	4.6	- 9%	*
25)	M	20	5'10"	165	5.4	5.5	5.4	5.4	4.5	20%	
26)	M	20	6'0"	155	4.7	4.6	4.6	4.6	4.6	0%	

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
27)	M	21	5'9"	200	4.1	5.1	4.6	4.6	4.4	5%
28)	M	23	5'11"	210	5.1	5.2	5.4	5.2	4.5	16%
29)	M	21	6'0"	145	3.5	3.6	3.9	3.7	4.6	-20%
30)	M	21	6'1"	175	6.1	6.2	6.4	6.2	4.7	32%
31)	M	20	6'0"	175	4.6	4.9	5.1	4.9	4.7	4%
32)	F	20	5'5"	118	3.0	3.1	3.0	3.0	3.3	- 9%
33)	F	22	5'3"	125	2.9	2.9	3.0	2.9	3.1	- 6%
34)	F	20	5'3"	135	3.2	3.3	3.4	3.3	3.2	3% *
35)	F	21	6'0"	132	3.6	3.7	3.6	3.6	3.6	0%
36)	F	20	5'8"	?	3.1	2.9	3.0	3.0	3.4	-12%
37)	F	20	5'6"	160	3.2	3.2	3.6	3.3	3.3	0%
38)	F	22	5'7"	140	3.7	3.5	3.7	3.6	3.3	9%
39)	F	21	5'11"	145	4.5	4.5	4.6	4.5	3.5	29%
40)	F	19	5'5"	130	3.3	3.4	3.3	3.3	3.3	0% *
41)	F	21	5'3"	112	3.2	3.3	3.4	3.3	3.2	3%
42)	F	19	5'5"	130	3.4	3.6	3.7	3.6	3.3	9% *
43)	F	20	5'9"	135	3.5	3.6	3.6	3.6	3.5	3%
44)	F	20	5'6"	118	3.9	3.8	3.8	3.8	3.3	15%
45)	F	22	5'8"	132	3.4	3.8	3.6	3.6	3.4	6% *
46)	F	19	5'9"	129	4.4	4.5	4.2	4.4	3.5	26%
47)	F	20	5'1"	110	2.5	2.6	2.7	2.6	3.1	-16% *
48)	F	20	5'4"	113	3.7	3.9	3.8	3.8	3.2	19%
49)	F	21	5'5"	120	3.8	3.7	4.0	3.8	3.2	19%
50)	F	20	5'4"	125	2.5	2.6	2.6	2.6	3.2	-19%
51)	F	21	5'9"	145	4.0	4.0	3.9	4.0	3.5	14%
52)	F	19	5'4"	115	3.0	3.1	3.2	3.1	3.2	- 3%
53)	F	21	5'8"	135	3.2	3.1	3.2	3.2	3.4	- 6%
54)	F	21	5'2"	105	2.7	2.9	3.0	2.9	3.1	- 6%

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
55)	F	21	5'0"	98	2.5	2.4	2.6	2.5	3.0	-17%
56)	F	20	5'5"	130	3.3	3.5	3.5	3.4	3.3	3% *
57)	F	19	5'6"	120	3.4	3.3	3.3	3.3	3.3	0%
58)	F	19	5'5"	134	3.6	3.7	3.8	3.7	3.3	12%
59)	F	19	5'9"	175	3.7	3.9	4.1	3.9	3.5	11%
60)	F	21	5'8"	140	4.1	4.2	4.3	4.2	3.4	24%
61)	F	19	5'5"	135	3.7	3.8	3.8	3.8	3.3	15%
62)	F	19	5'5"	150	3.7	3.6	3.6	3.6	3.3	9% *
63)	F	19	5'7"	145	3.7	3.8	3.8	3.8	3.4	11%
64)	F	21	5'6"	112	2.9	2.8	2.7	2.8	3.3	-15%
65)	F	22	5'8"	145	4.1	4.0	4.1	4.1	3.4	21%
66)	F	19	6'0"	170	4.5	4.6	4.7	4.6	3.6	28%
67)	F	19	5'10"	140	3.4	3.5	3.6	3.5	3.5	0%
68)	F	19	5'5"	125	2.9	3.0	3.1	3.0	3.3	- 9%
69)	F	21	5'5"	140	3.5	3.4	3.6	3.5	3.3	6% *
70)	F	20	5'5"	120	2.6	2.6	2.7	2.6	3.3	-21%
71)	F	21	5'5"	135	3.9	4.0	3.9	3.9	3.2	22%
72)	F	20	5'6"	150	2.9	3.3	3.1	3.1	3.3	- 6% *
73)	F	21	5'5"	115	3.4	3.5	3.4	3.4	3.2	6%

TRUMPETS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	20	6'0"	155	5.8	5.8	5.9	5.8	4.6	26%
2)	M	19	6'0"	155	4.9	4.9	4.9	4.9	4.7	4% *
3)	M	20	6'4"	225	4.4	4.9	5.0	4.8	4.9	- 2%
4)	M	21	5'11"	165	3.7	4.3	4.5	4.2	4.6	- 9%
5)	M	19	6'2"	180	5.3	5.8	5.9	5.7	4.8	19% *
6)	M	22	6'2"	145	4.6	4.4	4.5	4.5	4.7	- 4%
7)	M	19	6'2"	165	4.8	4.4	4.6	4.6	4.8	- 4%
8)	M	20	5'11"	150	4.9	5.0	5.0	5.0	4.6	9%
9)	M	20	5'11"	165	5.1	5.1	5.1	5.1	4.6	11%
10)	M	19	5'10"	145	3.9	4.4	4.4	4.2	4.5	- 7% *
11)	M	19	6'4"	203	6.0	6.2	6.1	6.1	4.9	24%
12)	M	21	5'11"	180	5.1	5.0	4.9	5.0	4.6	9% *
13)	M	20	5'11"	145	5.3	5.2	5.4	5.3	4.6	15%
14)	M	21	6'1"	150	5.0	5.4	5.4	5.3	4.7	13%
15)	M	20	5'9"	140	5.5	5.3	5.8	5.5	4.4	25% *
16)	M	19	5'8"	150	4.7	4.5	4.7	4.6	4.4	5%
17)	M	22	5'6"	145	4.5	4.6	4.5	4.5	4.2	7%
18)	M	21	5'9"	150	4.5	4.7	4.8	4.7	4.4	7% *
19)	M	19	5'9"	145	5.0	4.9	5.0	5.0	4.5	11% *
20)	M	19	6'0"	175	5.0	5.1	5.2	5.1	4.7	9%
21)	M	20	5'6"	175	4.1	4.6	4.5	4.4	4.3	2%
22)	M	19	6'0"	190	5.7	5.7	5.8	5.7	4.7	21%
23)	M	21	6'0"	160	4.8	5.1	5.0	5.0	4.6	9%
24)	M	19	6'0"	165	5.7	5.5	5.7	5.6	4.7	19%
25)	M	21	5'9"	190	4.7	5.1	5.1	5.0	4.4	14%
26)	M	19	5'11"	150	5.1	5.2	5.3	5.2	4.6	13%
27)	M	21	5'11"	180	4.5	4.6	4.6	4.6	4.6	0%

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
28)	F	20	5'3"	?	3.5	3.5	3.4	3.5	3.2	9%
29)	F	20	5'5"	120	3.2	3.3	3.3	3.3	3.3	0%
30)	F	20	5'2"	112	3.1	3.1	3.0	3.1	3.1	0%
31)	F	19	5'5"	160	3.7	3.8	3.8	3.8	3.3	15%
32)	F	19	5'6"	122	3.5	3.7	3.7	3.6	3.3	9%

FRENCH HORN PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	22	5'7"	132	3.5	3.6	3.6	3.6	4.3	-16%
2)	M	19	6'2"	170	5.4	5.5	5.6	5.5	4.8	15%
3)	M	21	5'10"	173	6.1	6.2	6.3	6.2	4.5	38%
4)	M	20	5'10"	155	4.1	4.4	4.5	4.3	4.5	- 4% *
5)	M	20	5'10"	160	4.6	4.8	4.7	4.7	4.5	4%
6)	M	19	6'3"	195	5.3	5.2	5.4	5.3	4.8	10% *
7)	M	19	6'3"	165	4.9	5.1	5.4	5.1	4.8	6%
8)	M	20	5'9"	145	4.2	4.0	3.8	4.0	4.4	- 9%
9)	M	21	5'7"	150	4.1	4.4	4.6	4.4	4.3	2%
10)	M	20	6'1"	175	4.9	5.1	5.0	5.0	4.7	6% *
11)	M	21	6'0"	180	5.8	6.2	6.4	6.1	4.6	33%
12)	M	20	5'9"	130	5.0	4.8	5.0	4.9	4.4	11%
13)	M	21	5'10"	160	5.0	5.1	5.0	5.0	4.5	11%
14)	M	20	5'10"	165	4.9	4.9	4.8	4.9	4.5	9%
15)	F	20	5'4"	108	2.9	3.0	2.8	2.9	3.2	- 9%
16)	F	21	5'7"	135	3.4	3.4	3.4	3.4	3.4	0%
17)	F	20	5'7"	130	3.3	3.3	3.4	3.3	3.4	- 3%
18)	F	20	5'7"	135	3.7	4.1	3.8	3.9	3.4	15%
19)	F	20	5'9"	?	3.8	3.8	3.9	3.8	3.5	9% *
20)	F	19	5'7"	120	3.7	3.8	3.9	3.8	3.4	12% *
21)	F	20	5'7"	130	3.3	3.4	3.3	3.3	3.4	- 3%
22)	F	19	5'7"	175	4.1	4.0	4.2	4.1	3.4	21%
23)	F	20	5'6"	125	3.3	3.4	3.3	3.3	3.3	0% *
24)	F	19	5'9"	140	4.2	4.1	4.2	4.2	3.5	20%
25)	F	21	5'9"	145	3.7	3.7	3.7	3.7	3.6	6%
26)	F	22	5'4"	100	3.5	3.5	3.3	3.4	3.2	6%
27)	F	22	5'7"	150	3.5	3.2	3.4	3.4	3.3	3%

TROMBONE PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	20	5'10"	155	4.9	5.0	5.1	5.0	4.5	11%
2)	M	20	6'0"	165	4.6	5.0	5.0	5.0	4.6	9%
3)	M	19	5'10"	160	4.6	4.4	4.5	4.5	4.5	0%
4)	M	21	6'2"	160	5.6	5.7	5.5	5.6	4.8	17%
5)	M	21	5'9"	155	4.1	4.1	4.0	4.1	4.4	- 7%
6)	M	19	5'11"	230	5.9	5.8	5.8	5.8	4.6	26%
7)	M	20	5'9"	172	5.1	5.0	5.1	5.1	4.4	16%
8)	M	21	6'4"	165	5.5	5.5	5.3	5.4	4.9	10%
9)	M	20	6'0"	145	5.1	4.8	4.9	4.9	4.6	7%
10)	M	19	5'8"	150	5.0	5.1	5.1	5.1	4.4	16%
11)	M	22	5'8"	140	4.8	4.8	4.8	4.8	4.4	9%
12)	M	20	5'11"	175	5.1	5.2	5.4	5.2	4.6	13% *
13)	M	21	5'11"	160	5.0	5.1	5.0	5.0	4.5	11%
14)	M	20	6'1"	180	5.0	5.2	5.1	5.1	4.7	9%
15)	M	21	5'11"	167	4.8	5.0	5.2	5.0	4.6	9%
16)	M	21	6'0"	190	5.1	5.1	5.1	5.1	4.6	11%
17)	M	19	6'4"	187	4.9	5.0	4.9	4.9	4.9	0%
18)	M	20	5'10"	185	5.6	5.5	5.5	5.5	4.5	22%
19)	M	19	5'11"	165	4.8	4.8	4.9	4.8	4.6	4%
20)	F	21	5'6"	155	4.1	4.2	4.2	4.2	3.3	27%

EUPHONIUM PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	21	6'2"	155	6.0	5.9	6.1	6.0	4.8	25%
2)	M	22	5'11"	185	4.6	4.6	4.7	4.6	4.5	2%
3)	M	20	6'1"	170	5.4	5.6	5.8	5.6	4.7	19% *
4)	M	20	5'10"	165	4.5	4.5	4.4	4.5	4.5	0%
5)	M	19	5'11"	186	4.9	5.0	5.1	5.0	4.6	9%
6)	M	20	5'11"	150	5.3	5.7	5.7	5.6	4.6	22%
7)	M	21	5'11"	175	4.9	4.8	4.6	4.8	4.6	4%
8)	M	20	6'4"	265	6.4	6.6	6.9	6.6	4.9	35%
9)	M	22	5'10"	180	4.8	4.9	5.0	4.9	4.5	9% *
10)	M	19	5'10"	150	4.3	4.5	4.3	4.4	4.5	- 2%
11)	M	21	5'8"	157	4.3	4.0	4.3	4.2	4.4	- 5%
12)	M	19	6'0"	180	5.0	4.9	4.9.	4.9	4.7	4%
13)	M	20	5'9"	150	5.3	5.2	5.2	5.2	4.4	18%
14)	M	22	5'6"	140	4.7	4.6	4.9	4.7	4.2	12%
15)	F	20	5'5"	128	3.1	3.1	3.0	3.1	3.3	- 6%
16)	F	21	5'5"	145	3.7	3.8	3.8	3.8	3.2	19%
17)	F	19	5'10"	130	3.8	3.8	3.9	3.8	3.5	9% *
18)	F	20	5'6"	122	3.6	3.7	3.7	3.7	3.3	12%

TUBA PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	20	5'10"	195	5.4	5.3	5.2	5.3	4.5	18% *
2)	M	21	5'11"	185	4.9	5.4	5.5	5.3	4.6	15%
3)	M	20	6'2"	205	5.9	5.9	6.0	5.9	4.8	23% *
4)	M	20	6'1"	200	5.3	5.4	5.2	5.3	4.7	13%
5)	M	21	5'10"	140	4.2	4.3	4.3	4.3	4.5	- 4%
6)	M	21	5'11"	220	5.0	5.1	5.2	5.1	4.6	11% *
7)	M	19	5'11"	170	5.3	5.3	5.5	5.4	4.6	17%
8)	M	20	5'10"	160	5.2	5.1	5.1	5.1	4.5	13%
9)	M	20	5'11"	157	5.8	5.8	5.9	5.8	4.6	26%
10)	M	21	5'9"	150	4.5	4.9	5.2	4.9	4.4	11%
11)	M	20	5'11"	150	4.9	4.8	4.9	4.9	4.6	7%
12)	M	19	6'2"	235	6.1	6.1	6.1	6.1	4.8	27%
13)	M	22	5'6"	170	5.2	5.2	5.2	5.2	4.2	24%
14)	M	21	5'11"	180	5.4	5.3	5.3	5.3	4.6	15% *
15)	M	20	6'0"	172	5.1	5.3	5.5	5.3	4.6	15%

FLUTE PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	20	5'8"	140	4.3	4.2	4.2	4.2	4.4	- 5% *
2)	M	22	5'8"	140	4.4	4.8	4.9	4.7	4.3	9%
3)	M	19	5'11"	155	4.6	4.5	4.5	4.5	4.6	- 2%
4)	F	21	5'5"	115	2.5	2.4	2.6	2.5	3.2	-22%
5)	F	19	5'8"	135	3.5	3.3	3.4	3.4	3.4	0% *
6)	F	19	5'4"	110	3.2	3.4	3.4	3.3	3.2	3%
7)	F	21	5'0"	115	2.8	2.7	3.0	2.8	3.0	- 7% *
8)	F	21	5'7"	100	2.6	2.6	2.5	2.6	3.4	-24%
9)	F	20	5'10"	150	3.7	4.0	4.0	3.9	3.5	11%
10)	F	20	5'6"	131	3.8	3.8	3.9	3.8	3.5	9%
11)	F	22	5'6"	139	3.2	2.7	2.8	2.9	3.3	-12%
12)	F	20	5'2"	112	3.2	3.3	3.2	3.2	3.1	3%
13)	F	21	5'2"	115	3.0	3.0	3.0	3.0	3.1	- 3%
14)	F	20	5'4"	127	3.7	3.7	3.9	3.8	3.2	19%
15)	F	21	5'6"	125	3.4	3.5	3.5	3.5	3.3	6% *
16)	F	21	5'10"	?	4.1	4.1	4.1	4.1	3.5	17%
17)	F	22	5'1"	122	2.8	2.8	2.7	2.8	3.0	- 7%
18)	F	20	5'4"	115	3.5	3.6	3.6	3.6	3.2	13%
19)	F	21	5'4"	127	2.4	2.4	2.6	2.5	3.2	-22%
20)	F	20	5'6"	130	3.7	3.8	3.7	3.7	3.3	12%
21)	F	18	5'8"	145	3.7	3.8	3.7	3.7	3.4	9%
22)	F	19	5'7"	130	4.7	4.8	4.8	4.8	3.4	41%
23)	F	19	5'3"	125	3.3	3.4	3.4	3.4	3.2	6%
24)	F	19	5'8"	?	3.9	4.3	4.0	4.1	3.4	21%

CLARINET PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	21	6'1"	210	5.3	5.7	5.7	5.6	4.7	19%
2)	M	22	5'8"	180	4.7	4.9	5.0	4.9	4.3	14%
3)	M	20	5'10"	155	5.3	5.1	5.4	5.3	4.5	18%
4)	M	20	6'0"	190	4.3	4.9	4.6	4.6	4.6	0% *
5)	M	20	5'10"	180	5.1	5.2	5.3	5.2	4.5	16% *
6)	M	19	6'2"	200	5.0	5.1	5.2	5.1	4.8	6% *
7)	M	20	5'9"	150	4.4	4.5	4.6	4.5	4.4	2%
8)	M	19	5'5"	135	4.9	4.8	4.7	4.8	4.2	14% *
9)	M	21	6'1"	184	4.8	4.7	4.7	4.7	4.7	0%
10)	M	20	5'11"	170	4.6	4.8	5.0	4.8	4.6	4%
11)	M	22	5'8"	130	4.7	4.7	4.8	4.7	4.3	9%
12)	M	19	5'11"	130	4.3	4.3	4.4	4.3	4.6	- 7%
13)	M	19	5'6"	140	3.9	4.0	3.7	3.9	4.3	- 9% *
14)	M	19	5'11"	185	4.0	4.0	3.9	4.0	4.6	-13%
15)	M	20	6'1"	180	4.7	4.7	4.1	4.5	4.7	- 4%
16)	F	21	5'6"	130	3.2	3.1	3.0	3.1	3.2	- 6%
17)	F	19	5'3"	135	3.7	3.6	3.8	3.7	3.2	16%
18)	F	20	5'6"	135	2.8	3.2	3.2	3.1	3.3	- 6%
19)	F	19	5'6"	135	3.6	3.6	3.8	3.7	3.3	12% *
20)	F	21	5'2"	112	2.5	2.9	2.9	2.8	3.1	-10%
21)	F	20	5'4"	130	3.4	3.2	3.3	3.3	3.2	3%
22)	F	21	5'2"	121	3.0	2.9	2.7	2.9	3.1	6% *
23)	F	21	5'5"	125	3.4	3.3	3.3	3.3	3.2	3%
24)	F	21	5'4"	120	3.9	3.9	3.8	3.9	3.2	22%
25)	F	21	5'4"	121	3.3	3.2	3.1	3.2	3.2	0%
26)	F	21	5'8"	123	4.4	4.5	4.5	4.5	3.4	32%

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
27)	F	19	5'3"	115	3.1	3.2	3.2	3.2	3.2	0% *
28)	F	20	5'5"	115	3.6	3.5	3.6	3.6	3.3	9% *
29)	F	22	5'4"	96	2.8	2.9	2.8	2.8	3.2	-13%
30)	F	19	5'2"	140	3.7	3.8	3.7	3.7	3.1	19%
31)	F	19	5'3"	105	2.7	2.5	2.8	2.7	3.2	-16% *
32)	F	22	5'7"	130	3.5	3.8	3.7	3.7	3.3	12%
33)	F	21	5'5"	118	2.5	2.6	2.7	2.6	3.2	-19%

OBOE PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	20	6'1"	185	4.7	5.2	4.6	4.8	4.7	2%
2)	M	21	6'0"	175	5.0	5.1	5.0	5.0	4.6	9%
3)	M	21	5'7"	150	5.0	5.2	5.4	5.2	4.3	21%
4)	M	20	5'10"	160	4.4	4.4	4.4	4.4	4.5	- 2%
5)	M	21	5'9"	140	3.2	3.8	4.0	3.7	4.4	-16%
6)	M	19	5'11"	155	4.3	4.5	4.2	4.3	4.6	- 7% *
7)	F	19	5'9"	150	4.0	4.2	4.3	4.2	3.5	20%
8)	F	21	5'10"	?	3.3	3.4	3.3	3.3	3.5	- 6%
9)	F	20	5'4"	?	2.8	3.1	3.0	3.0	3.2	- 6%
10)	F	22	5'2"	130	2.9	3.0	3.2	3.0	3.1	- 3%
11)	F	19	5'1"	105	2.6	2.5	2.6	2.6	3.1	-16%
12)	F	19	5'6"	120	3.0	3.1	3.0	3.0	3.3	- 9%
13)	F	21	5'1"	137	3.6	3.5	3.5	3.5	3.1	13%
14)	F	20	5'9"	150	3.7	3.8	3.7	3.7	3.5	6%
15)	F	20	5'2"	115	3.2	3.3	3.2	3.2	3.1	3%
16)	F	21	5'1"	?	3.1	2.9	3.1	3.0	3.1	- 3%

BASSOON PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference
1)	M	21	5'10"	175	4.1	4.1	4.2	4.1	4.5	- 9%
2)	M	20	6'0"	185	4.7	4.6	4.6	4.6	4.6	0%
3)	M	21	5'10"	160	4.5	4.6	4.6	4.6	4.5	2%
4)	F	19	5'6"	145	3.2	3.2	3.4	3.3	3.3	0%
5)	F	20	5'2"	110	2.9	3.0	3.0	3.0	3.1	- 3%
6)	F	19	5'1"	115	2.2	2.3	3.0	2.5	3.1	-19%

SAX PLAYERS

	Sex	Age	Height	Weight	Tests (1)	(2)	(3)	Average	Predicted Capacity	Difference	
1)	M	21	6'3"	160	5.5	5.3	5.6	5.5	4.8	15%	*
2)	M	20	6'0"	160	4.9	5.1	4.3	4.8	4.6	4%	*
3)	M	19	5'10"	150	4.7	5.1	5.0	4.9	4.5	9%	*
4)	M	20	5'11"	140	4.1	4.1	4.4	4.2	4.6	- 9%	
5)	M	19	6'4"	155	5.3	5.2	5.1	5.2	4.9	6%	
6)	M	20	6'2"	150	3.9	3.9	4.0	3.9	4.8	-18%	
7)	M	21	5'10"	170	5.9	5.9	5.8	5.9	4.5	31%	
8)	M	20	6'0"	155	5.0	5.0	4.8	4.9	4.6	7%	
9)	M	21	5'9"	175	5.2	5.3	5.6	5.4	4.4	23%	
10)	M	21	5'9"	165	3.8	4.0	3.9	3.9	4.4	-11%	*
11)	M	20	5'10"	140	3.8	3.5	4.0	3.8	4.5	-16%	
12)	M	22	6'2"	175	4.7	4.8	5.0	4.8	4.7	2%	
13)	M	19	5'11"	170	4.6	4.6	4.7	4.6	4.6	0%	
14)	M	19	6'0"	183	4.7	4.8	4.8	4.8	4.7	2%	*
15)	M	19	5'9"	136	4.6	4.8	4.7	4.7	4.5	4%	*
16)	F	19	5'8"	145	3.7	3.8	3.8	3.8	3.4	12%	
17)	F	20	5'3"	120	2.6	2.9	3.1	2.9	3.2	- 9%	
18)	F	20	5'3"	115	3.3	3.6	3.8	3.6	3.1	16%	
19)	F	21	5'7"	125	3.4	3.3	3.4	3.4	3.4	0%	
20)	F	19	5'5"	114	3.4	3.4	3.4	3.4	3.3	3%	
21)	F	21	5'4"	118	3.3	3.5	3.5	3.4	3.2	6%	*
22)	F	20	5'6"	120	3.5	3.5	3.5	3.5	3.3	6%	

Appendix II

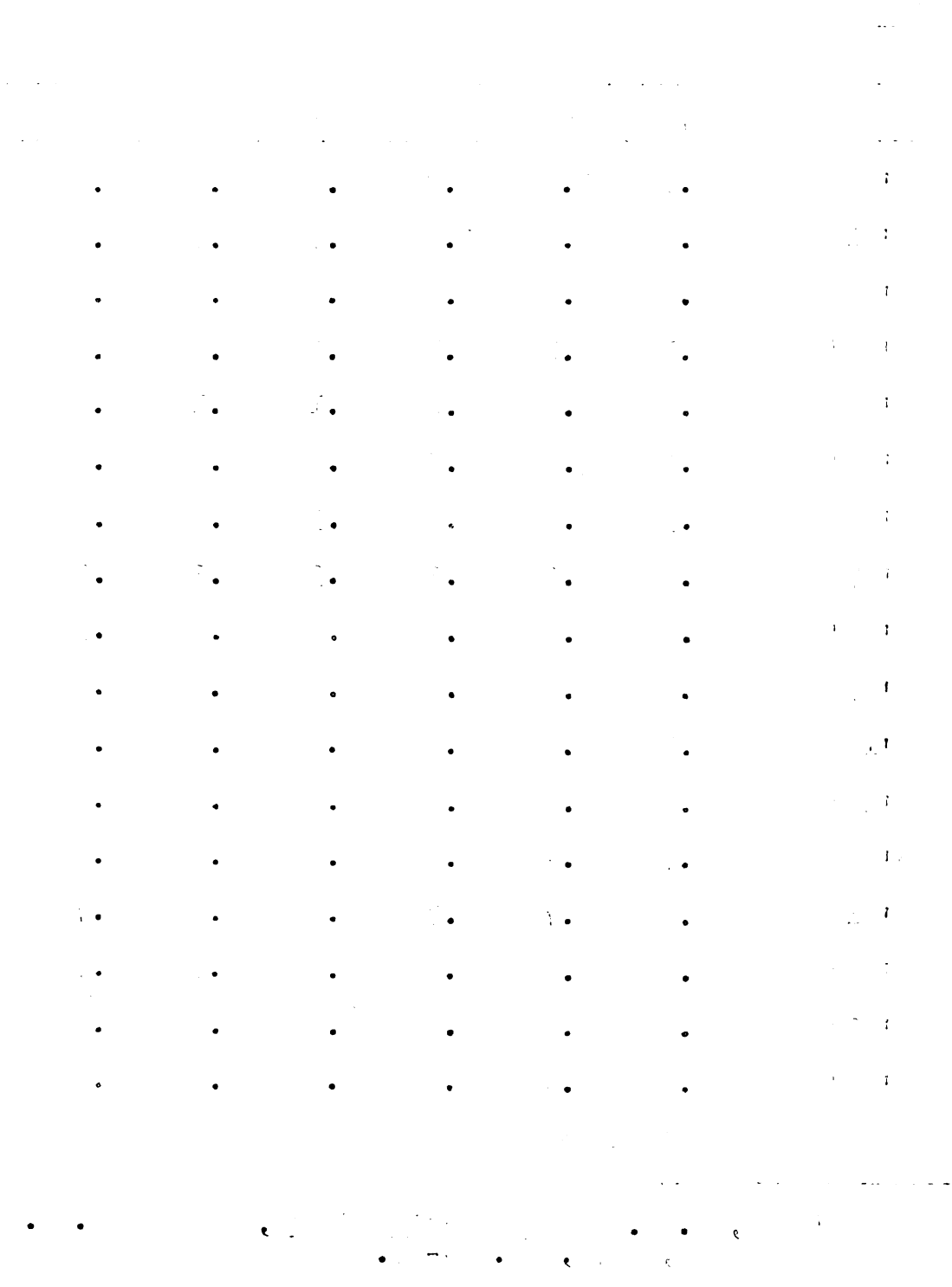
PREDICTED VITAL CAPACITIES[27]

Males

HEIGHT	AGE					
	18	19	20	21	22	23
5' 0"	3.9 *	3.9	3.9	3.8	3.8	3.8
5' 1"	4.0	4.0	3.9	3.9	3.9	3.9
5' 2"	4.0	4.0	4.0	4.0	4.0	4.0
5' 3"	4.1	4.1	4.1	4.0	4.0	4.0
5' 4"	4.2	4.2	4.1	4.1	4.1	4.1
5' 5"	4.3	4.2	4.2	4.2	4.2	4.2
5' 6"	4.3	4.3	4.3	4.3	4.2	4.2
5' 7"	4.4	4.3	4.3	4.3	4.3	4.3
5' 8"	4.4	4.4	4.4	4.4	4.3	4.3
5' 9"	4.5	4.5	4.4	4.4	4.4	4.4
5'10"	4.6	4.5	4.5	4.5	4.5	4.5
5'11"	4.6	4.6	4.6	4.6	4.5	4.5
6' 0"	4.7	4.7	4.6	4.6	4.6	4.6
6' 1"	4.8	4.7	4.7	4.7	4.7	4.7
6' 2"	4.8	4.8	4.8	4.8	4.7	4.7
6' 3"	4.9	4.8	4.8	4.8	4.8	4.8
6' 4"	5.0	4.9	4.9	4.9	4.9	4.8

* measurement in liters

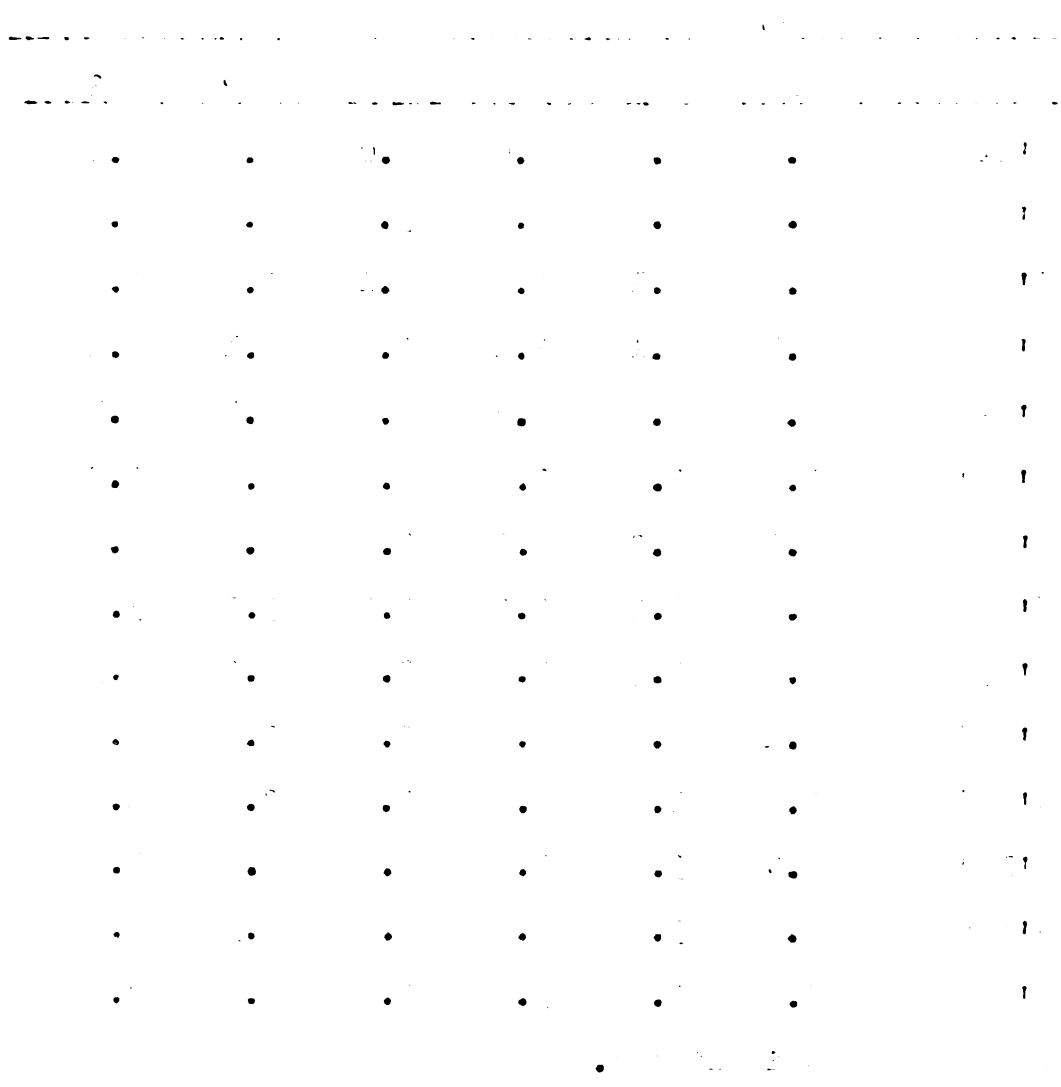
[27]Bass, B. H. Lung Function Tests, London: H. K. Lewis and Company, 1974, pp. 86-87.



Females

HEIGHT	AGE					
	18	19	20	21	22	23
4'11"	3.0 *	3.0	3.0	3.0	2.9	2.9
5' 0"	3.0	3.0	3.0	3.0	3.0	3.0
5' 1"	3.1	3.1	3.1	3.1	3.0	3.0
5' 2"	3.1	3.1	3.1	3.1	3.1	3.1
5' 3"	3.2	3.2	3.2	3.2	3.1	3.1
5' 4"	3.2	3.2	3.2	3.2	3.2	3.2
5' 5"	3.3	3.3	3.3	3.2	3.2	3.2
5' 6"	3.3	3.3	3.3	3.3	3.3	3.3
5' 7"	3.4	3.4	3.4	3.4	3.3	3.3
5' 8"	3.4	3.4	3.4	3.4	3.4	3.4
5' 9"	3.5	3.5	3.5	3.5	3.4	3.4
5'10"	3.6	3.5	3.5	3.5	3.5	3.5
5'11"	3.6	3.6	3.6	3.5	3.5	3.5
6' 0"	3.6	3.6	3.6	3.6	3.6	3.6

* measurement in liters.



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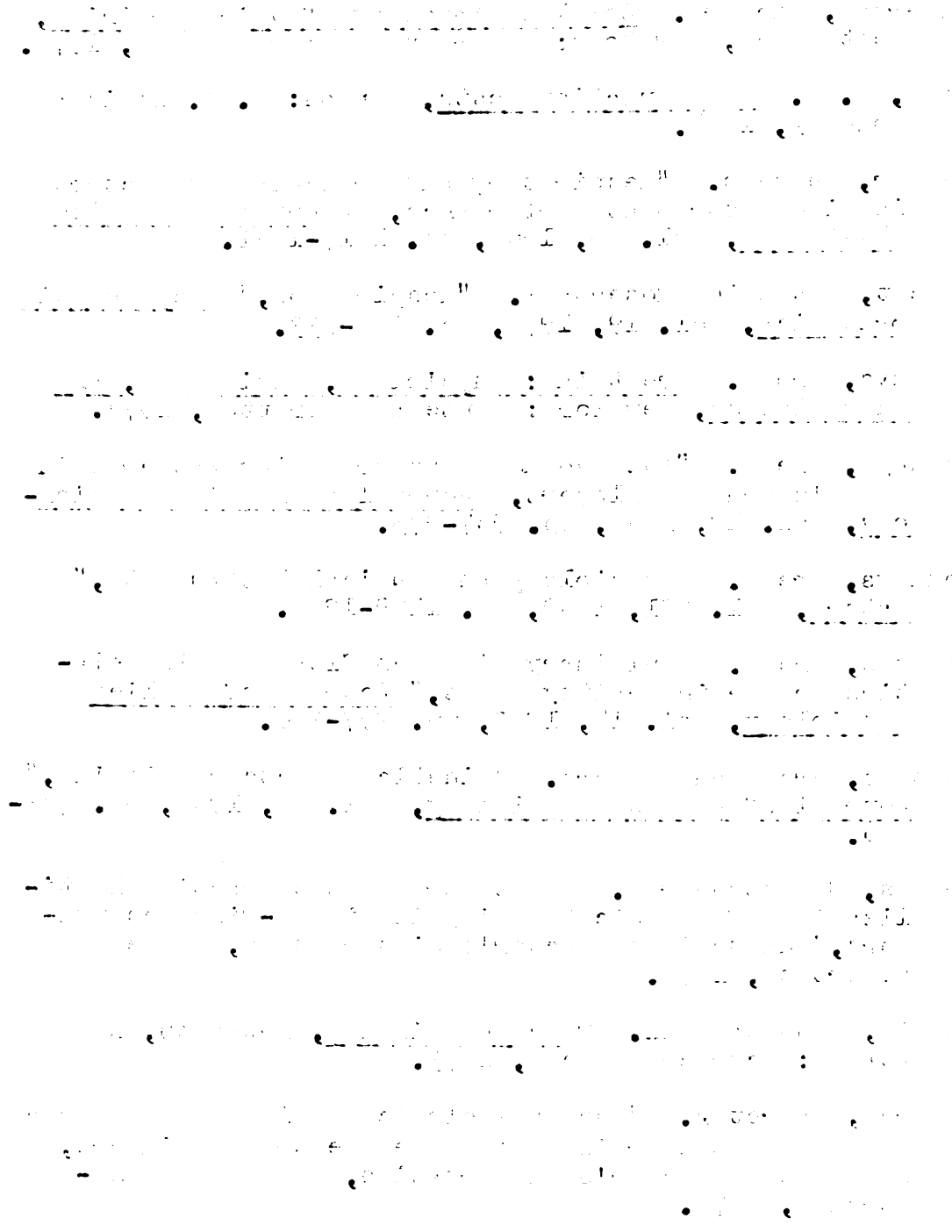

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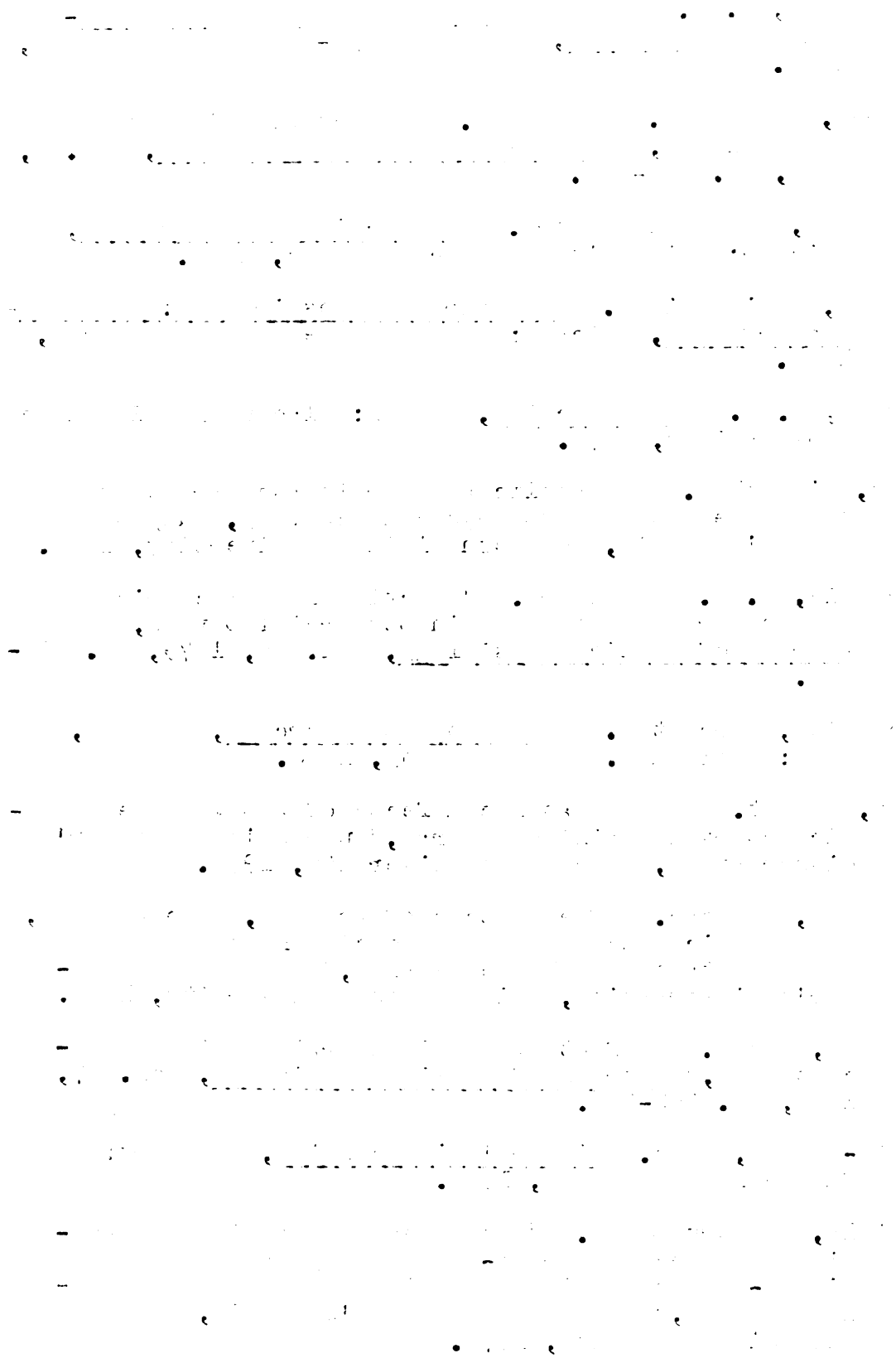

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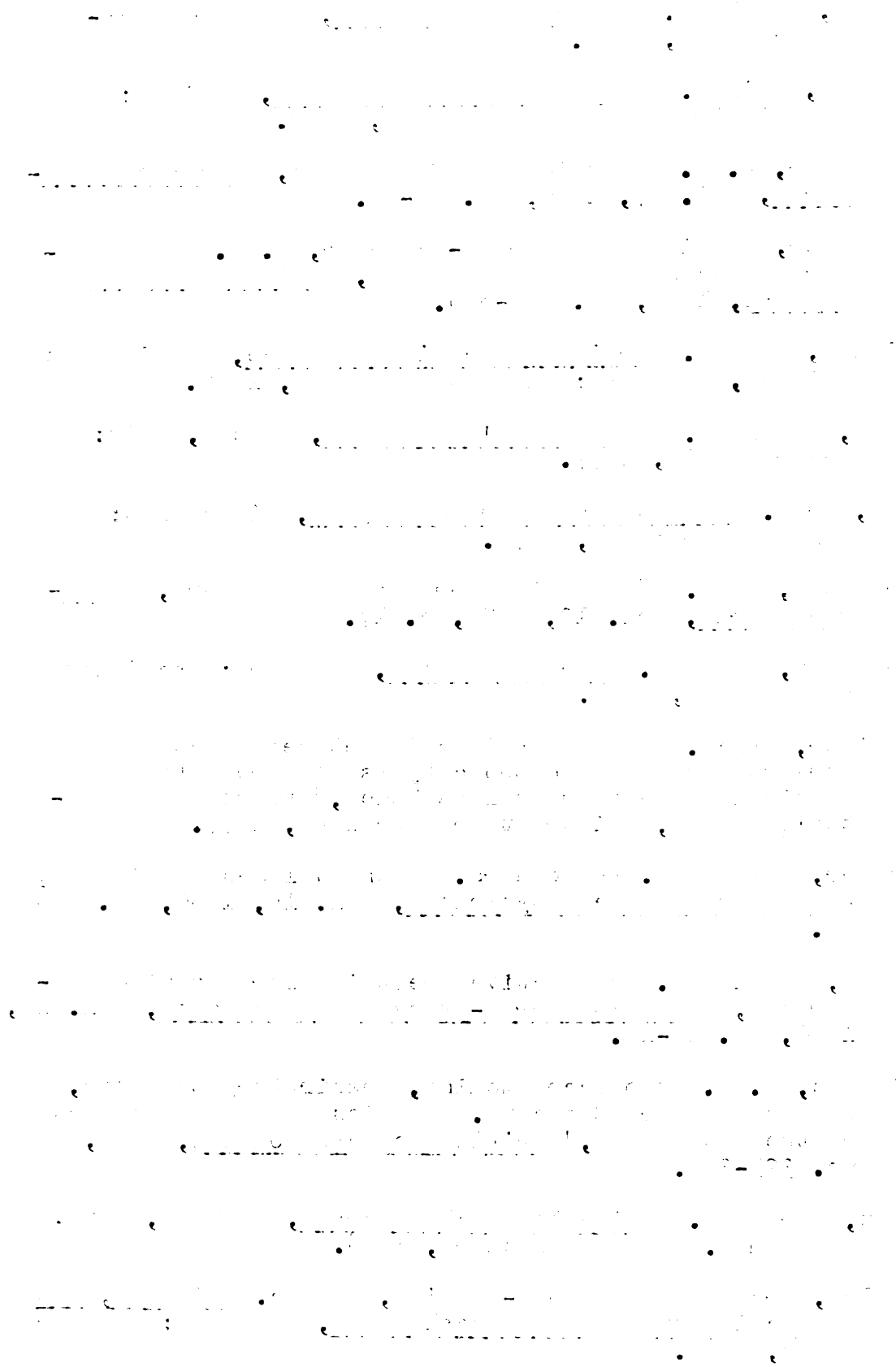

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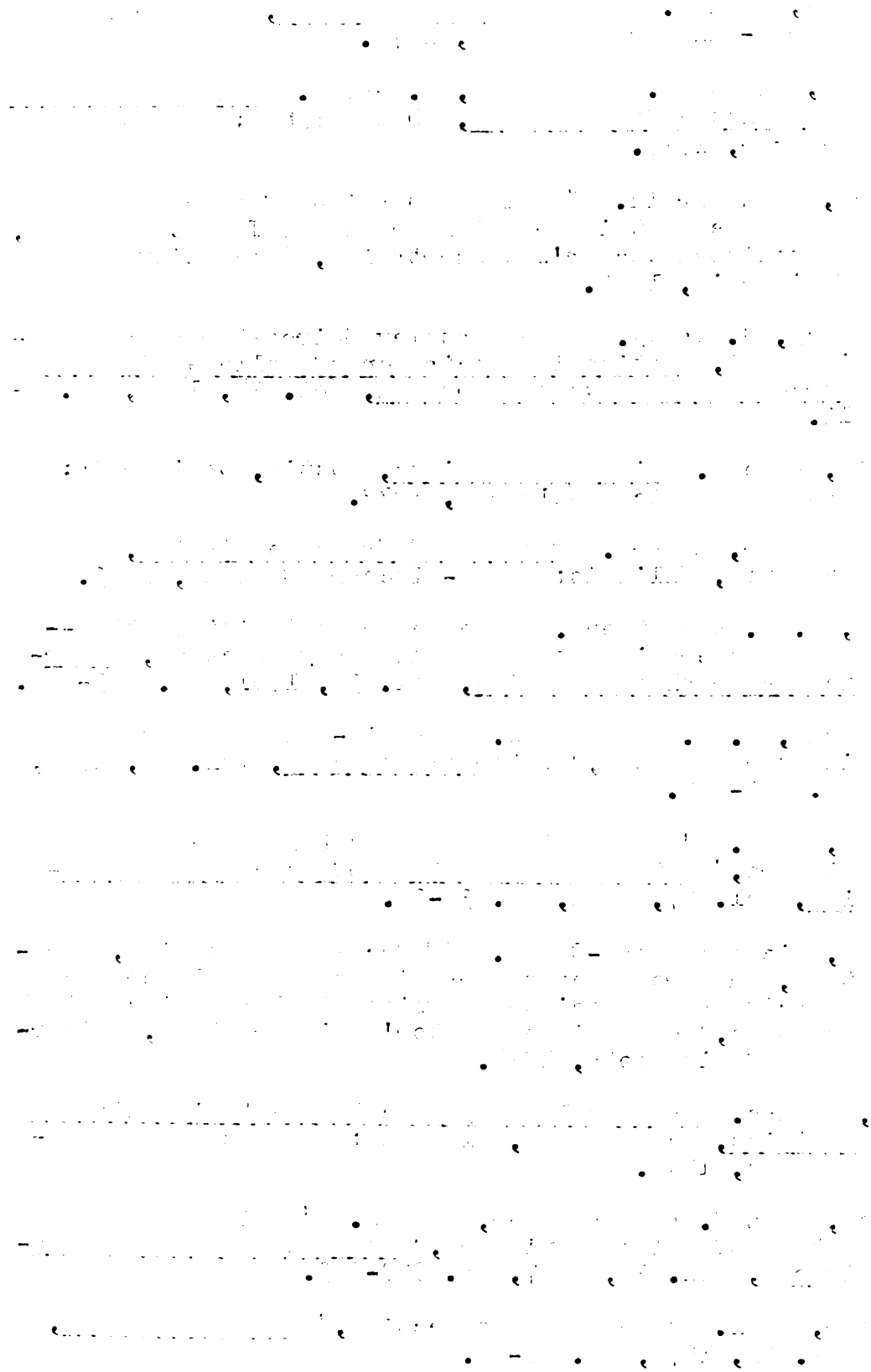

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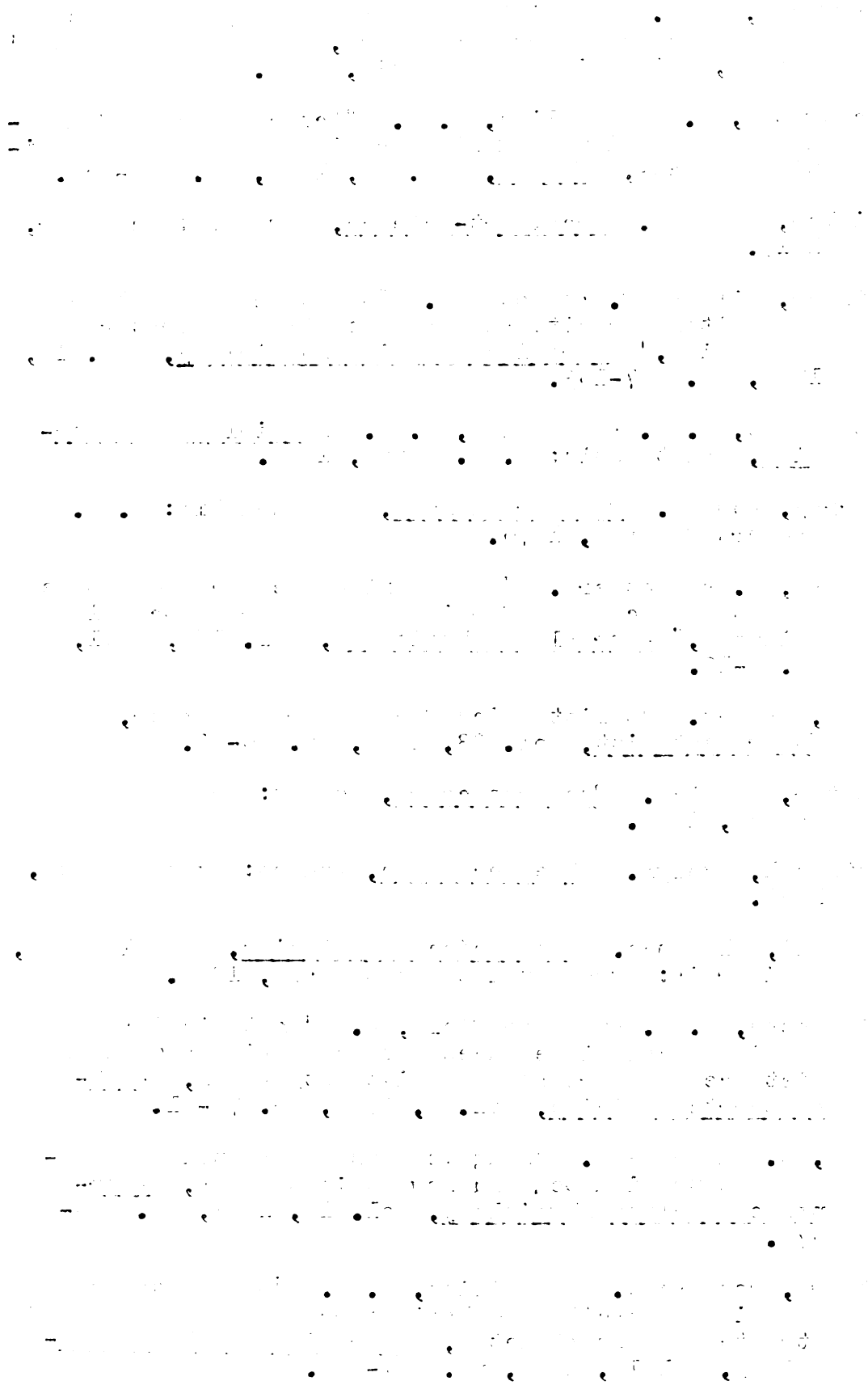

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