THE EFFECTS OF PHYSIOLOGY-BASED BREATH-MANAGEMENT INSTRUCTION ON PERFORMANCE ACHIEVEMENT OF SIXTH-GRADE CLARINETISTS

by

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A Dissertation Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Greensboro
1996

Approved by

Dissertation Advisor

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VANMIDDLESWORTH, JANE LEONA, Ph.D. The Effects of Physiology-Based Breath-Management Instruction on Performance Achievement of Sixth-Grade Clarinetists. (1996) Directed by Dr. James W. Sherbon.
111 pp.

The purpose of the study was to examine the effects of two methods of breath-management instruction on selected performance variables of sixth-grade clarinetists. Performance variables included tone quality, pitch stability of middle and clarion tones, pitch accuracy of middle and clarion tones, tonal duration of chalumeau, middle, and clarion tones; and soft and loud dynamic control of middle and clarion tones.

Three groups of intact classes of sixth-grade clarinetists were assigned to one of three breath-management groups: physiology-based (PBM); traditional (TBM); and comparison, no breath management (CBM). Over a seven-week period, the treatment for each group consisted of 13 researcher-taught sessions of 20 minutes each, totaling 260 minutes of instruction. Twelve pretest and posttest measurements of clarinet performance, listed above, were obtained and the data were analyzed by computing 12 one-way univariate analyses of covariance on posttest scores (dependent variables) with corresponding pretest scores serving as covariates.

Analysis of the results, including post-hoc Tukey analysis, indicated that there was a significant effect by group on the measure of soft dynamic control of the middle register tone ($p = .01$), in that subjects in the PBM group played significantly louder when playing as softly as they could play than did subjects of the CBM group ($p = .007$) and louder, approaching significance ($p = .066$), than subjects of the TBM group. Measures of tone quality, pitch stability and pitch accuracy of middle and clarion register tones, tonal duration of

chalumeau, middle, and clarion register tones; soft dynamic control of a clarion register tone, and loud dynamic control of middle and clarion register tones did not produce significant differences by group. Although there was a significant difference between groups for one measure, there was no evidence that physiologic breath-management instruction improves clarinet performance more than traditional or no breath-management instruction. Relevant contributions of the study include an investigation of the effects of two methods of breath management on clarinet performance measures, descriptive information regarding clarinet performance across different clarinet tonal registers, and use of a *Visi-pitch* instrument to measure pitch stability and pitch accuracy.

APPROVAL PAGE

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November 12, 1996
Date of Acceptance by Committee

September 20, 1996
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CHAPTER I

INTRODUCTION

Faulty breath management often restricts clarinet students from mastering certain performance skills. Operationally defined as efficient control of the muscles of inspiration and expiration during wind instrument and vocal performance, breath management may affect performance of variables such as the production of acceptable tone quality, pitch stability, pitch accuracy, tonal duration, and dynamic control. Breath management during wind instrument performance consists of rapid, deep inhalations followed by prolonged exhalations. During exhalations the performer controls the speed of air leaving the body (airflow rate), the airway pressures in the body, and the lung volumes necessary for performance.

In addition, when performing on a wind instrument, each register of the instrument may contain particular performance requirements. Bouhuys (1964) recorded differences in air pressure and airflow rates for low and high, and for soft and loud tones of the clarinet. The beginning clarinetist may experience distinct performance problems for each register of the clarinet, chalumeau (from notated E_3 to approximately D_4), middle (approximately from notated E_4 through Bb_4), and clarion (from notated C_5 through C_6) (Kennan, 1970) due to varying physiologic requirements of the registers. As students gain proficiency on the clarinet, they become aware of difficulties in tone quality, stability of tones, pitch accuracy of tones (Stubbins, 1965), soft dynamic control, and loud dynamic control of tones in the three clarinet registers. Instructional emphasis on breath management of clarinet performance may improve performance of one register of the clarinet while having no effect on performance skills of other clarinet registers. Therefore, improved breath management may improve performance of some clarinet register tones more than others.

Research in this area is not new, as studies regarding breath management during music performance have been published in scientific journals since 1874. Specifically, representative research on relationships between variables of breath management and selected performance variables during wind instrument performance have been published by Akgün and Özgönül (1967), Anastasio and Bussard (1971), Barton and Laws (1902), Berger (1965), Bouhuys (1964), Frucht (1937), Navrátil and Rejsek (1968), Roos (1936, 1938, 1940), Stone (1874), and Vivona (1968). Physiologic variables of vocal performance have been studied by Bouhuys (1977), Miller (1986), Sundberg (1987), and Sundberg and Leanderson (1983).

In addition to descriptive studies, five experimental studies from the current literature emerge as foundations for conducting research on breath management. Barnes (1987), Phillips (1983), Phillips and Sehmann (1990), Phillips and Vispoel (1990), and Sehmann (1990) measured performance variables of subjects receiving breath-management instruction and compared these with measurements of subjects receiving no breath-management instruction. In these studies, the method of instruction was designed individually by the researchers without subjects receiving specific instruction regarding the physiologic aspects of performance. Additionally, none of these studies investigated the effects of breath-management instruction on different registers of the voice or the instruments studied. In each study, the performance of subjects studying breath management improved significantly on specific variables over the performance of subjects receiving no specific breath-management instruction, thus supporting the premise that quality wind performance requires development of breath-management skills. Therefore, achieving efficient control of the breath may reduce, in turn, some clarinet performance problems.

Supportive Literature

Physiology

When performing, young clarinet students often demonstrate inefficient breath-management techniques that may be attributed to confusion or unfamiliarity regarding muscular control. Ambiguity, therefore, may originate from many sources, but particularly from lack of appropriate instruction, or the presence of conflicting information regarding proper procedures of controlling the breath during clarinet performance. For example, inconsistencies in the research and methodological literature may accelerate confusion on fundamental physical movement, such as pulling the abdomen in or pushing the abdomen out during exhalation. Representative articles pertaining to physical movement, breath management, and wind instrument performance by Cramer (1981), Kelly (1983), and de Wetter-Smith (1978), do not describe specifically the direction of muscular movement during expiration, and instructional articles by Boschma (1989) and Walker (1989) clearly are in opposition. Walker's description of flute performance included the following: "While exhaling, the muscles surrounding the sides of the chest, abdomen, diaphragm, and waist pull inward and upward, forcing the air out" (p. 58). In contrast, Boschma (1989) described breathing for trumpet performance as keeping the torso sides expanded while performing: "try to keep the sides (the lower ribs) expanded, carefully checking the tension of the abdominal, back, and diaphragm muscles" (p. 43). These brief citations from the literature reflect the presence of contradictory approaches to breath management for wind instrument performance. These contradictions, however, may exist partly as a result of differing breath management demands for flute, trumpet, and clarinet performance; variance in successful technique for efficient wind instrument performance; or the propagation of inadequate information about appropriate breathing procedures for performing on wind instruments. The general inconclusiveness in the literature and among teachers regarding breath management, however, is obvious, thus justifying further study.

Published research on physiologic behaviors during wind instrument performance is insufficient for practical instruction and application. Most existing respiratory performance physiologic research has been conducted by physiologists and published in technical, scientific journals that are difficult for musicians to interpret (Huttlin, 1982). In addition, physiologic and scientific information is not easily conveyed by researchers for practical use by clarinetists. For example, although Bouhuys (1964) published information regarding relationships of airway pressures and airflow rates to pitch and dynamics, there are no clarinet pedagogy books currently available that indicate what these relationships may be or how knowledge of airflow rates might improve clarinet performance.

Not only is it difficult to understand physiologic processes of clarinet performance, but students may be confused also by pedagogy that attempts to explain these processes without regard for the physical attributes causing these things to happen. For example, teachers may ignore or fail to include vital aspects of physiology when teaching. In *The Clarinet and Clarinet Playing*, Pino (1980) stated that, next to relaxation, airflow is the most important part of playing the clarinet. "The truth is that all other aspects of playing should be considered less important than airflow because they actually depend upon it." (p. 45). Yet, at no time in the book does Pino follow his statements with an explanation of relationships of airflow and clarinet playing, thus limiting his work to his perceptions of airflow and air pressure. Pino (1980) described observations of greater teaching success by describing his own perceptions of airflow and air pressure rather than objective, specific, physiologic applications. Research involving clarinet performance has not focused on improving the understanding of respiratory performance physiology. Of 230 dissertations listed in the *Clarinet* magazine (Perone, 1989; Perone, 1990) none of the listings were directed toward breath management. In R. Colwell (Ed.), *The Handbook for Research in Music Education* (1992) only fluoroscopic studies of the oral cavity were listed under the chapter, "Research on the Teaching of Instrumental Music." In the chapter titled "Research of Biomechanical and Physiological Processes in Relation to Musical Performance," breathing was mentioned only once and research pertaining to breath management was not cited. Pedagogues who wish to improve their teaching methods by better understanding the physiology of wind instrument performance find little current continuing research in the field.

Traditional methods of teaching breath management for clarinet performance often are based on the use of imagery, which may or may not have been derived from scientific information. However, the premise of the current study is that scientists and artists will advance knowledge and instructional methodology more effectively by working together than by working in isolated environments. Although traditional methods of teaching breath management may improve student performance, it is possible that physiology-based methods of teaching breath management would improve performance quality more expeditiously. Therefore, regardless of perceptions among teachers, empirical work and supportive research literature, very little conclusive evidence exists that enhances pedagogical applications of clarinet performance.

Summary of the Problem

For clarinetists' performances to meet current performance standards, developed control of the inspiratory and expiratory muscles is necessary, a control that is often lacking in young clarinetists. In addition, many clarinet students do not effectively apply breath-management techniques even when instructed in these areas. This lack of application may be due to teachers' faulty perceptions, inconsistencies in the literature, inappropriate pedagogical applications, and specific register demands of the clarinet. The combination of these factors produces a general ambiguity surrounding this topic, thereby enforcing the need for additional study employing pedagogical techniques based on physical understanding of breath management.

Purpose of the Study

The purpose of this study was to examine the effects of two methods of breath-management instruction on selected performance variables of beginning clarinet students. The principal question serving as the research objective was stated: Will the method of breath-management instruction–physiology-based, traditional, or comparison, have an effect on performance variables of tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones?

Null Hypotheses

1. There is no significant difference between group means of tone quality measurements ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

2. There is no significant difference between group means of pitch stability measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

3. There is no significant difference between group means of pitch stability measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

4. There is no significant difference between group means of pitch accuracy measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

5. There is no significant difference between group means of pitch accuracy measurements clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

6. There is no significant difference between group means of tonal duration measurements of clarinet chalumeau register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

7. There is no significant difference between group means of tonal duration measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

8. There is no significant difference between group means of tonal duration measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

9. There is no significant difference between group means of soft dynamic control measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

10. There is no significant difference between group means of soft dynamic control measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

11. There is no significant difference between group means of loud dynamic control measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

12. There is no significant difference between group means of loud dynamic control measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

Summary

Published research regarding the most effective method of teaching breath-management to young clarinetists is minimal, and available information regarding breath-management instruction is often conflicting and ambiguous. Since breath management is believed by many teachers to be foundational to clarinet performance, it is important to isolate and examine methods of clarinet instruction to determine the most effective pedagogical procedures. The purpose of the current study was to compare performance skills of sixth-grade clarinetists who had received traditional imagery-based breath-management instruction with those who had received physiology-based breath-management instruction. Conclusions from this study may help music educators make instructional decisions that will facilitate the teaching and learning of efficient breath management in clarinet performance.

CHAPTER II

REVIEW OF THE LITERATURE

Published research on respiratory wind instrument performance physiology can be divided into four classifications: (a) measurements of airway pressures and flow rates during wind instrument performance, (b) measurements of lung volumes and capacities of wind instrumentalists, (c) measurements of respiratory muscle activity during wind instrument performance, and (d) performance achievement following breath-management instruction. The current study is structured to obtain information about the effects of method of breath-management instruction on clarinet tone quality, pitch stability, pitch duration, and dynamic control. Two methods of instruction will be utilized: physiology-based instruction and traditional instruction without physiologic explanations. Information gleaned from research of wind instrument performance physiology constitutes the basis of information that will be taught during the physiology-based breath-management instruction method. Studies in wind instrument physiology are summarized below to support and enhance the current research, providing information upon which this research is built.

Airway Pressures and Flow Rates

During performance, wind instrumentalists inhale rapidly at controlled lung volumes and exhale for prolonged periods, generating the airflow rates and air pressures necessary to produce sound on a specific instrument

(Bouhuys, 1964). Although studies on airway pressures required for wind instrument performance have been conducted for more than one hundred years (Anastasio & Bussard, 1971; Barton & Laws, 1902; Berger, 1965; Frucht, 1937; Navrátil & Rejsek, 1968; Roos, 1936, 1938, 1940; Stone, 1874; Vivona, 1968), Bouhuys (1964) is recognized as the first to publish research findings on airway pressures, airflow rates, and lung volumes during wind instrument performance.

Typically, researchers measured airway pressures by attaching a manometer[1] (Barton & Laws, 1902; Berger, 1965; Frucht, 1937; Navrátil & Rejsek, 1968; Roos, 1936, 1938, 1940; Stone, 1874; Vivona, 1968) or a pressure gauge (Anastasio & Bussard, 1971) to a small tube, placed in the corner of the mouth of the instrumentalist during wind instrument performance. Stone (1874) reported measurements of air pressures present in the oral cavities of eight professional wind instrumentalists during wind instrument performance. Oral cavity pressures of mezzo forte tones were measured for low pitches and high pitches on oboe, clarinet, bassoon, French horn, cornet, trumpet, euphonium, and bombardon (tuba). The range of brass pressures varied more than did those of the woodwind performers and for all instruments, except clarinet, pressures were greater for high pitches than for low pitches.

Barton and Laws (1902) measured airway pressures of three brass instrumentalists during performance (tenor trombone, trumpet, and cornet) to determine pressures necessary for changes in pitch and loudness on each

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[1] A water manometer consists of a bottle of water containing a tube which measures the displacement of the water in centimeters when air pressure is introduced into the open end of the tube.

instrument. A summary of the air pressures present for low and high pitches of the nine instrumentalists measured by Stone (1874) and Barton and Laws

Table 1
Minimal and Maximal Intraoral Air Pressure Values Performed at Mezzo Forte Dynamic Levels, Recorded by Stone (1874) and Barton and Laws (1902), Calibrated to mm. of H_2O, and Compiled by Roos (1936)

Instrument	minimal	maximal	Author
Tuba (bombardon)	75	900	Stone
Trombone	130	1220	Barton and Laws
Horn	125	675	Stone
Cornet	250	850	Stone
Cornet.	130	840	Barton and Laws
Trumpet	300	825	Stone
Trumpet.	160	680	Barton and Laws
Oboe	225	425	Stone
Clarinet	200	375	Stone

(1902) was compiled by Roos (1936) and is reproduced in Table 1.

Roos (1936, 1938, 1940) measured airway pressures and airflow rates produced by professional musicians while playing flute and oboe. In 1936, he recorded flute pressures ranging from 20 mm. of H_20 for C_4 of the flute to 250 mm. H_20 for the high pitch, C_7 while performing at mezzo forte dynamic levels. The greatest increase in pressure was found between C_6 and C_7 during which pressure rose from 86 mm. of H_20 at C_6 to 250 mm. of H_20 at C_7.

Roos (1938) further studied the airway pressures and flow rates of the flageolet tones, or the tones in the fourth register of the flute, observing various pressures expended to produce tones using different fingerings. Roos determined that production of flageolet tones requires significantly greater airway pressure than those required to produce tones in the first three octaves. In measuring oboe airway pressures, Roos (1940) noted that the pressure in the mouth cavity rose with the pitch of the tone, with pressures ranging from 190 mm H_2O for the lowest note on the oboe (B_3) to 550 mm H_2O for A_6 with the third octave requiring the greatest pressure change. A summary of Roos's research indicates that pressures exerted by the oboist were much more stationary than the pressures exerted by the flute, and pressure exerted playing the oboe was notably higher than that required for flute performance.

Frucht (1937) measured air pressures and flow rates of brass instrumentalists at differing pitches and dynamic levels. He found that higher and louder pitches required greater pressures and airflow rates.

Berger (1965) measured intraoral air pressures, quantity of air used (airflow rate), and rapidity of articulation of ten adult male trumpet players while tones were being produced at varying pitches and dynamic levels. Loud tones were found to require a greater quantity of airflow for all pitches than did soft tones. However, for soft tones, the middle range pitches required less air than extreme-range pitch levels.

Vivona (1968) recorded mouth pressures during performance on trombone and concluded that mean pressures in the oral cavity differ among subjects, and those pressures differ with each individual between performances of the same pitch at the same dynamic level. Consistency of oral pressure on different days and trials did not appear to affect the quality of performance on the trombone.

Navrátil and Rejsek (1968) measured pulmonary function and intraoral pressures during wind instrument performance of piano, mezzo forte, and forte tones as performed by 84 professional wind instrument players from the Czech Philharmonic Orchestra. Pulmonary function measurements were compared with those of 83 professional glassblowers from two factories near Prague and a third group of 63 patients who had been diagnosed with chronic asthmatic bronchitis. Analysis of the results indicated that average pressures increased with loudness in all instruments from about 20 to 50 millimeters of Mercury (mm. of Hg) with maximum values at 140 mm. of Hg for the trumpet. Clarinet pressures in the study ranged from 45 to 48 mm. of Hg from piano to forte playing.

Mouth air pressure measured in hundredths of a pound per square inch and loudness measured in decibels were recorded for four oboe performers by Anastasio and Bussard (1971) to determine pressure changes required to produce varying pitches on the oboe. An air pressure profile of pitch and air pressure, with intensity held constant, was plotted and averaged using data from 151 trials. Anastasio and Bussard concluded that, for the oboe, a positive correlation exists between air pressure requirements and pitch, and between air pressure requirements and loudness.

While the results of all of the previous studies were obtained using a manometer or an air pressure gauge, studies by Bouhuys are more conclusive, containing more elaborate measurements. Bouhuys (1964) measured mouth pressures during performance and lung function at rest of 42 professional wind instrumentalists on 15 different instruments with a balloon-catheter.[2] In this study, airflow rate was measured with a wet spirometer[3] by: (a) measuring the largest amount of air that could be exhaled in one breath (Vital Capacity or VC) by blowing out one full breath into the spirometer; (b) blowing a pitch on an instrument for a set number of seconds after full inhalation; and (c) exhaling the remainder of the air remaining in the lungs into the spirometer. To calculate the airflow rate, Bouhuys divided the volume of air remaining in the lungs after exhalation (Residual Volume or Rv) by the time in seconds that the tone was produced.

In 1968, Bouhuys published measurements of lung volume changes simultaneously with the mouth pressures exerted by placing the subject into a volume-displacement body plethysmograph.[4] This procedure allows lung volumes to be recorded during playing of a wind instrument without attaching measuring devices to the subject's mouth. Bouhuys concluded that in order to maintain a constant pitch and dynamic level on a wind instrument, one must maintain a constant mouth pressure and airflow rate. He observed that with

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2 Airway pressures can be recorded by placing a small, air-filled balloon, connected to a pressure transducer and amplifier via a thin tube, inside the mouth of a wind instrumentalist during performance.

3 A spirometer consists of a drum inverted over a chamber of water, the drum counterbalanced by a weight. On breathing through a tube connected to the drum, the drum rises and falls, and an appropriate recording is made on another drum (Guyton, 1966, p. 551).

4 A body plethysmograph is a large box that measures lung volume changes, in which the subject is seated with his or her head out and a seal around the neck. The box incorporates a spirometer that records changes in chest volume.

increasing dynamic levels, both mouth pressures and flow rates increase. Important findings from Bouhuys's studies show that variance in pitch and dynamics may be a function of airway pressure, airflow rate, and lung volumes. For example, Bouhuys (1964, 1968) recorded moderate airway pressures and small flow rates for oboe performance, high pressures and small flow rates for trumpet and French horn performance, and low pressures and high flow rates for flute and tuba performance. He found that pressures required to sound tones on wind instruments vary from about .75 centimeters of water pressure (cm. H_2O) for tuba performance to 200 cm. H_2O for trumpet performance. In comparison, pressures required to produce tones on brass instruments include a wider range of pressures than those required to play woodwind instruments.

A summary of the conclusions from these studies indicates that to produce tones acceptable for traditional music performance standards, wind instrumentalists must develop control of airflow rate, airway pressures, and lung volumes, and make physical adaptations in direct relationship to the instrument played. Because pressure requirements differ among instruments and to avoid confusion among teachers and students, pedagogues should avoid generalizations regarding air pressure and airflow requirements of instrumental performance. In addition, teachers and performers should learn the requirements of the specific instruments being taught.

Lung Volumes and Capacities

A survey of research on wind instrument respiratory performance physiology revealed that researchers of lung volume and capacity have typically compared measurements of physiologic parameters of wind instrumentalists with subjects who did not play wind instruments. In the lung volume and capacity studies, researchers measured the useful amount of air supply in the lungs of wind instrumentalists (VC) and compared results with lung volumes and capacities measured in subjects with no wind instrument experience or predicted norms of subjects determined by weight, age, and gender. To facilitate understanding of the research which has been conducted regarding lung volumes and capacities, important terms are defined below.

Maximal Expiratory Pressure (MEP): the maximal positive airway pressure which can be exerted from the end of maximal inspiration.

Maximal Inspiratory Pressure (MIP): the maximal negative airway pressure which can be exerted from the end of maximal expiration.

Residual Volume (RV): Amount of air remaining in the lungs from the end of maximal expiration.

Total Lung Capacity (TLC): Maximal amount of air in the lungs after maximal inspiration, including Residual Volume, which cannot be exhaled.

Expiratory Reserve Volume (ERV): the maximal amount of air which can be expired from the end of normal expiration.

In the study by Bouhuys (1964) in which airflow rates and airway pressures were measured during wind instrument performance, the lung function of 40 professional male wind instrumentalists was measured and compared to the results from healthy male subjects and tables of expected values according to gender, height, age, and weight. VC of the younger age groups (24-34 and 35-44 years) was greater significantly in wind players than in controls. In addition, VC in wind players was significantly greater than expected according to age and height.

Akgün and Özgönül (1967) compared breathing patterns and lung volumes of 17 male zurna (a Turkish double-reeded instrument) players with those of 17 male control subjects of similar age, height, and weight. VC and maximal expiratory and inspiratory flow rates were significantly smaller in zurna players than in control subjects. RV and RV/ TLC were greater in wind players than in control subjects. Akgün and Özgönül also concluded that the smaller VCs and flow rates of the wind players may be due to the fact that more wind players than controls had a history of heavy smoking.

In addition to the study of intraoral pressures reviewed previously, Navrátil and Rejsek (1968) measured lung volumes of 83 glassblowers near Prague, 63 patients with a diagnosis of chronic asthmatic bronchitis, and 73 healthy men, in addition to the 84 professional wind instrument players from the Czech Philharmonic Orchestra. There were no significant lung volume differences between woodwind and brass players, or between wind players and healthy control subjects.

Borgia, Horvath, Dunn, von Phul, and Nizet (1975) recorded lung capacities and volumes using a respirometer (function similar to a spirometer) of 47 French hornists. There were no significant differences between musicians' measurements and standardized measurements for lung capacity and volume of healthy adults.

Tucker, Faulkner, and Horvath (1971) compared measurements of 45 male brass players to results in two tables of standard normal values and found that the wind players measured significantly greater VCs, TLCs, ERVs, RVs, and RV/TLC ratios than the expected values.

Stauffer (1968) measured VC of 63 male wind instrumentalists in the U.S. Navy Band and found VC to be 8.7% greater in the wind instrumentalists than in a table of normal values according to height and age. Since the Navy is a selected population and the control subjects used to determine normal values consisted of hospital patients, results are questionable.

Huttlin (1982) measured vital capacities of 376 university students (ages 18-23); 90 subjects had no training on a wind instrument or voice, and 286 subjects were music majors with a wind instrument or voice as their major instrument. All subjects were instructed to inhale and exhale into a spirometer, with the largest of three attempts recorded. Test results were compared with a table of normal values based on the subject's height, age, and gender. Although no statistical procedures were calculated, Huttlin concluded that VC of the wind instrument players appeared to be greater than VC of the group with no wind instrument or vocal experience and greater than values from the table of normal values. In particular, the mean VC of brass players was 9.9% greater than VC of the values from the table of normal values.

Schorr-Lesnick (1988) administered pulmonary function tests and questionnaires about health attitudes and habits to 113 musicians. Thirty-one string and percussion players served as the control group while 34 vocalists and 48 wind instrumentalists served as the experimental group. Pulmonary function testing of the string and percussion players was not different significantly from the 34 vocalists and 48 wind instrumentalists measured.

VanMiddlesworth (1978) measured lung volumes, breathing patterns at rest, maximal airway pressures, peak flow rates, and pulse rate responses to a 30-second breath hold at increased airway pressures of 16 non wind musicians and 33 wind musicians. VC of both male and female wind instrumentalists in the study were significantly greater than VC of the male and female control subjects but not greater than expected values for gender, height, and age of healthy, non smoking males and females (Morris, Kosk, & Johnson, 1971).

Researchers attempting to determine whether or not the respiratory system adapts to the continued stress of playing wind instruments have reached conflicting conclusions. Studies by Bouhuys (1964), Huttlin (1982), Stauffer (1968), and Tucker, Faulkner and Horvath (1971) indicate that wind instrumentalists may have larger lung volumes and capacities than subjects who do not play wind instruments. However, Akgün and Özgönül (1967), Borgia, Horvath, Dunn, von Phul, and Nizet (1975); Navrátil and Rejsek (1968), Schorr-Lesnick (1988), and VanMiddlesworth (1978) found no significant lung volume differences when comparing instrumentalists to the expected values according to gender, age, height, and weight of healthy adults.

More descriptive research by physiologists and musicians is needed to determine respiratory factors of wind instrument performance. One reason that music teachers and performers teach erroneous information to students may be that it is difficult to find answers to their own questions of what transpires physiologically during wind instrument performance. There are still questions about wind instrument performance physiology that have not been fully answered by the scientific community. If beginning music students are taught objective information about respiratory actions during wind instrument performance, this new generation of wind instrumentalists may develop a heightened interest in and communication with the scientific community toward furthering advancements in scientific understanding of wind instrument performance. These research advancements may, in turn, produce new teaching methods.

Respiratory Muscle Activity

Respiratory muscle activity has been measured during brass performance (Berger, 1968; Cugell, 1986) and vocal performance (Bouhuys, Mead, & Proctor, 1966; Sundberg & Leanderson, 1983). Berger (1968) studied the pattern sequence of activity of the internal intercostals, the external intercostals, the rectus abdominis, and the external abdominal oblique muscles of two college-age trumpeters by recording muscular activity using surface electromyography.[5] By measuring onset of Muscle Activity Potential (MAP), or the moment that muscles activated for performance, Berger concluded that MAP onset time ranged from .12 to .33 seconds preceding a trumpet tone, and that MAP onset time appeared to be earlier for high pitches than for low pitches. Berger concluded that the increase of MAP onset time with increases in tonal frequency appeared to positively correlate with increases in intraoral air pressures and tonal frequency reported in Berger (1965). Berger noted that during multiple articulations within one breath, the muscles did not return to their previous resting position and during fast articulation, only internal and external abdominal oblique muscles exhibited pulse activity. Berger noted that the diaphragm muscle was activated during expiration only when lung volumes were high, apparently acting as a braking mechanism for the elastic recoil of the

[5] Surface electromyography measures levels of muscle fiber activity by placing surface bipolar electrodes, filled with electrode jelly, over muscle sites. Electrodes are attached to an electromyograph to amplify and record muscle action.

lungs.

In an effort to determine the relative contributions of the thoracic and abdominal muscles during expiration while playing brass instruments, Cugell (1986) measured volume changes of the chest cage and abdomen of four experienced brass players (two trumpet players, one tuba player, and one French horn player) and an amateur penny whistle player using inductive plethysmography.[6] Cugell found that measurements of the two trumpet players and the French horn player were similar while measurements of the tuba player and penny whistle player were significantly different from those of the high brass players. Cugell concluded that the variation found among performers was attributed to differences in requirements of the different instruments played. Consistent with all performers was the fact that all combined their rib cage and abdominal muscles to expire in a smooth, controlled manner, with both abdomen and rib cage muscles contracted to achieve this. Quoting a study by Wade (1954), in which flouroscopic observation of the diaphragm of a singer showed no diaphragmatic action, Cugell concluded that the rib cage and abdominal muscles predominately control expiration for wind instrument performance.

Use of the diaphragm muscle during forced expiration has been studied in vocal research (Bouhuys, Proctor, & Mead, 1966; Sundberg & Leanderson, 1983). Bouhuys, Proctor, and Mead (1966) measured muscular forces necessary to maintain a constant sub glottal pressure for a sustained tone by

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[6] The inductive plethysmograph consists of a wire sewn into elastic binders that encircle the mid-chest and lower abdomen. Each binder is connected to an oscillator which measures volume changes.

vocalists and determined that, in order to maintain a constant sub glottal pressure of 7 cm. H_2O pressure, the vocalists added active inspiratory muscle force for the first half of a 30-second tone. The researchers observed that the expiratory muscles began to contract with increasingly greater force as the tone continued.

Sundberg and Leanderson (1983) measured and recorded muscular activation during sustained airway pressure and during sudden air pressure changes, such as when singing octave intervals. In this study two strategies were found to be present during sustained airway pressure; one singer sustained a lasting diaphragmatic activity throughout the phrase while three other singers activated the diaphragm only during inspiration. However, when the latter three singers rapidly lowered the airway pressure at high lung volumes the diaphragm muscle was activated, thus braking the elastic recoil of the lungs and other expiratory forces. These two studies indicate that, at least in some instances, the diaphragm may not be completely passive during singing.

Some empirical information has recently become available regarding specific muscle action during controlled breathing for wind instrument performance. However, questions remain regarding the role of the diaphragm during expiration. Research should be conducted to determine the extent, if any, of diaphragmatic contraction during expiration among different instruments and performers.

Breath-Management Instruction

Barnes (1987), Phillips (1983), Phillips and Sehmann (1990), Phillips and Vispoel (1990), and Sehmann (1990) examined the effects of breath-management instruction on musical performance. With the exception of

Barnes (1987), these studies included measurements of abdominal and thoracic displacement and vital capacity.

Barnes (1987) investigated the effects of class voice instruction and song instruction on vocal performance, vocal knowledge, and attitude of 113 college elementary education majors. In measures of vocal performance, posttest ANOVAs among groups revealed a significant difference for vocal projection but not for tone quality.

Phillips (1983) specifically examined pitch accuracy, pitch duration, pitch intensity, and pitch range achievement associated with breath management instruction. Phillips's subjects included second, third, and fourth grade singers (N = 44) who were randomly assigned to either a breath-management instruction group or a control group. Based upon the results of a multivariate analysis of covariance conducted on four dependent measures of singing ability (pitch range, pitch intensity, pitch duration, and pitch accuracy) along with three covariate measures of breathing (abdominal displacement, thoracic displacement, and vital capacity), Phillips concluded that pitch accuracy, vocal range, and tonal intensity were affected significantly by training techniques.

Phillips and Sehmann (1990) investigated the effects of breath-management instruction on selected performance achievement and respiratory function of brass players. Twenty college-level trumpet, horn, and trombone players were randomly assigned to one of two groups. The experimental group received 15 minutes of instruction during each of five weekly lessons. The control group did not receive instruction in breathing. Subjects in the experimental group showed greater abdominal displacement following instruction; however, tone quality and duration were not affected significantly.

Phillips and Vispoel (1990) investigated the effects of vocal instruction with and without breath management emphasis on college students majoring in elementary education (N = 43). Three intact classes were randomly assigned treatment conditions: vocal instruction with breath-management emphasis, vocal instruction without breath-management emphasis, and no vocal instruction. The treatment consisted of ten-minute sessions, twice weekly, for a period of ten weeks. Vocal knowledge, attitude, and vocal performance of range, pitch duration, pitch accuracy, vocal quality, thoracic movement, and abdominal movement served as dependent variables with treatment method serving as the independent variable. In the area of vocal performance, mean scores for both vocal instruction groups were significantly higher than the control group for highest pitch ($p < .05$) and vocal quality scores were significantly greater ($p < .05$) for the treatment group receiving breath-management instruction over the treatment group receiving vocal instruction without breath management instruction. Phillips and Vispoel concluded that breath-management instruction and vocal instruction are beneficial to vocal performance.

Sehmann (1990) investigated the effects of group breath-management instruction on thoracic displacement, abdominal displacement, vital capacity, range, duration, and tone quality of 61 elementary brass students. An experimental group receiving breath-management instruction produced significantly higher scores ($p < .05$) on measures of abdominal displacement, pitch range, and pitch duration than a control group.

Experimental studies of the effects of breath-management instruction on wind performers and singers indicate that breath-management instruction may affect performance. Therefore, breath-management instruction may improve some clarinet performance variables. Effects of methods applied to breath-management instruction have not been thoroughly studied, and, therefore, achievement of breath-management skills may be dependent, to some extent, upon method of breath-management instruction.

Summary

The literature supports assumptions that the human respiratory system responds in three ways to increased airway pressure and the deep, controlled breathing required for wind instrument performance. Wind instrumentalists practice extensively, developing control of air volumes, airflow rates, and air pressures needed to play wind instruments. However, traditionally, instrumentalists are not aware of the specific bodily functions that are enacted during wind instrument performance. Therefore, because of the unconscious physiologic responses that instrumentalists develop to perform successfully on wind instruments, it is possible that the conscious understanding and adaptation of physiologic aspects such as airflow rates, airway pressures, and lung volumes, in addition to breath-management instruction, may enhance wind instrument performance. This study compares performance achievement of middle-school clarinetists who have received breath-management instruction, including physiologic explanation, with middle-school clarinetists who have received breath-management instruction employing traditional exercises without physiologic explanations.

CHAPTER III

PROCEDURES

Introduction

The purpose of the study was to investigate the effects of two methods of breath-management instruction on certain performance variables of sixth-grade clarinetists. Breath management for clarinetists was operationally defined as efficient control of the muscles of inspiration and expiration during clarinet performance. The independent variable, instruction, consisted of three levels of treatment: physiology-based, traditional, and no breath management. Traditional breath-management instruction was defined as implementation of musical exercises utilizing either no explanation or use of imagery to describe the instructional procedures. Effects of the treatment were examined on as many clarinet registers as feasible, across twelve performance measures serving as dependent variables. These measures included tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones. Tone quality was not measured across registers because the tone quality measure was determined from adjudicators' scores of a musical etude consisting exclusively of notes in the middle register, the only notation these beginning students had been taught prior to the pretest. Tonal duration was the only measure of the chalumeau register due to testing time limitations and limitations of the *Visi-pitch*. Testing procedures were designed by the researcher for the purpose of obtaining objective measurements of the twelve dependent variables. To control for group mean differences present before treatment, pretest measurements of each dependent variable were covaried with their corresponding posttest variable in the statistical analysis.

Permission to perform the study was secured from principals and band directors of the participating schools, the parents of each student, and the University of North Carolina at Greensboro Human Subjects Review Board (See Appendix A for sample letter of consent). Specific procedures used in the selection of subjects and administering the experimental process for the two methods of breath-management instruction are presented below, thus establishing foundational information on techniques and applications.

Subjects

All beginning sixth-grade clarinet students (N = 38) attending two middle schools in central North Carolina (Brown Middle School, Thomasville, North Carolina, and Jamestown Middle School, Jamestown, North Carolina) served as subjects for the study. There were two woodwind classes of approximately 30 students each at Brown Middle School, one with 13 clarinetists and the other with 15, and one woodwind class of approximately 30 woodwind students, 10 of whom were clarinetists, at Jamestown Middle School.

Principal considerations in the selection of these schools were class scheduling, researcher proximity, program similarity, and student homogeneity. Class scheduling and researcher proximity were important so the researcher could serve as instructor for all three groups. All schools within a 10-mile radius of The University of North Carolina at Greensboro that met scheduling requirements were surveyed, and the Thomasville and Jamestown schools were identified as the two that were the most analogous regarding program similarity and student homogeneity. Program similarity was determined by class size and instrumentation, instructional texts, and teacher goals. Both band directors utilized Best in Class (Pearson, 1982) student texts and emphasized similar first-year goals for beginning instruction. To determine first-year goals, the researcher studied the band directors' recent lesson plans and concert literature for the sixth-grade band and interviewed the band directors regarding first-year student goals in such areas as tone production, hand positioning, posture, articulation, and pitch range. Student homogeneity was determined by assessing student background (classified as rural for both schools), and age at the onset of band instruction (sixth grade for both schools). After the schools were identified and to further verify homogeneity, the researcher personally interviewed students to ensure that none of the clarinetists had received private clarinet instruction, all had received instruction from only one band director, and all students had studied clarinet for no longer than six months.

After determining that the schools, teachers, and students met the selection criteria, three intact groups of clarinet students were extracted from their respective mixed woodwind classes and assigned to one of three treatment groups: physiology-based breath-management instruction (PBM), traditional breath-management instruction (TBM), and no breath-management instruction (CBM), the latter a comparison group. Because the one class with 10 clarinetists attending Jamestown Middle School normally received 45-minute instructional sessions five days per week, and the two classes with clarinetists at Brown Middle School (one with 13 clarinetists and the other with

15 clarinetists) received instruction two or three times a week for 45-minute sessions on an alternating week schedule, it was more appropriate for the class at Jamestown Middle School to serve as the comparison group, CBM (N = 10). Therefore, each of the two classes of clarinetists at Brown Middle School were assigned randomly to one of the two treatment groups, PBM (N = 15) and TBM (N = 13).

Treatment

The researcher, a professional clarinetist, instructed all groups two or three times a week, on an alternating schedule, so that the three treatment groups received the same amount of instructional time during the study. All clarinet students in both schools completed the study, with the exception of one who was truant and another who moved from the district. Data from these two students were eliminated.

Each of the three groups of subjects, PBM, TBM, and CBM, attended two or three 20-minute group clarinet lessons per week, on an alternating schedule, during the seven-week treatment period, for a total of 13 lessons each. Instruction for each of the three groups was provided by the researcher and took place during regular band class. Since sixth-grade clarinetists in these schools were normally taught in their respective mixed woodwind classes as described above, clarinetists from the three classes received instruction at a separate location. Table 2 illustrates a representative week of the alternating schedule, with instruction for Day 6 continuing with the Day 2 schedule.

Table 2
Schedule of Instruction for Alternating Weeks

	Day of Week and Times of Instruction				
Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
PBM Group	1:25-1:45		1:25-1:45		1:25-1:45
TBM Group		1:25-1:45		1:25-1:45	
CBM Group	2:25-2:45		2:25-2:45		2:25-2:45

Treatment Description

Treatment for the three groups consisted of two components: (a) a 5-minute core of instructional material covering clarinet performance fundamentals which was identical for each of the three groups; and (b) one of the three 15-minute instructional approaches, physiology-based breath management, traditional breath management, or no breath management. Instruction for the latter group included a "traditional" segment during each class to replace the breath-management instruction and complete the 20-minute instructional period. To provide a specific explanation of instructional strategies, the content of the core instruction and the three treatments are explained below and additional information is presented in Appendix B.

Core Training. To determine criteria for the content of the core instruction that was taught to all subjects, the researcher constructed and sequenced lessons based on the subject areas included in the chapters titled "Principles for Woodwinds" and "The Clarinet" in The Teaching of Instrumental Music

(Colwell & Goolsby, 1992). Subject areas taught in the core instructional material consisted of: holding the clarinet; care of the instrument; reed care and maintenance; introduction of fingering and note recognition of extended range pitches, E_3 through C_6; staccato and legato articulation techniques; two octave chromatic scale; and C, F, G, Bb, and D major scales.

Physiology-Based Method of Breath-Management Instruction (PBM). PBM was devised by the researcher from the premise that age-appropriate physiology instruction would improve musical performance by promoting student understanding of the rationale and procedures of breath-management techniques (stated in Chapter I). Therefore, PBM was based on the assumption that comprehension of breath-management factors would promote student awareness of the importance of practicing exercises such as long tones, with subsequent understanding leading to improved efficiency of student practice methods and achievement of an end goal of improved student performance. In addition, comprehension of breath-management factors by both teachers and students was expected to promote more effective teacher instruction and increased teacher-student communication than the traditional method of teaching without physiologic approaches.

The physiology-based method of breath management utilized in this study was divided into two parts, inspiration and expiration. Part I was designed to improve inspiratory muscle control, and to introduce awareness of the importance of high lung volumes and rapid, deep, inspiratory flow rate. Part II incorporated materials on developing control of expiratory muscles, air pressures, airflow rates, and lung volumes. Pedagogical exercises designed to develop inspiratory and expiratory control were constructed from the foundations provided by published research covering these elements. Treatment methods included exercises and visual explanations of the mechanics of inspiration and expiration based on the procedures of objective studies reviewed in Chapter II.

In Part I, methods for the development of inspiratory muscle control included exercises designed to promote correct posture for clarinet performance, to achieve abdominal relaxation and expansion during inspiration, and to reduce tension in the chest and shoulders. In addition to performing the exercises, subjects viewed muscular movement during diaphragmatic contraction by means of an anatomical doll and diagrams constructed to reinforce the concepts of correct muscular movement during inspiration.

Additionally in Part I, subjects were made aware that clarinet performance requires high lung volumes and rapid, efficient inspiratory flow rates. Subjects attempted to produce maximal pressures on a pressure gauge [7] after minimal inspiration as compared with maximal pressures produced after maximal inspiration. These pressures were compared with those produced when actually playing the clarinet. To improve rapid, deep inhalation, subjects were instructed to inspire for a preset number of beats before producing a tone on the clarinet. Subjects competed to determine who could produce the longest duration of a clarinet tone after only one inspiration. During repetitions of the exercise, tempo and the number of beats allowed for inspiration were varied by the researcher.

[7] A pressure gauge is a device that measures air pressure in pounds per square inch.

The focus of the first section of Part II, expiratory muscle control, included exercises to encourage control of the abdominal muscles and relaxation of the shoulders. In addition, presentations of printed diagrams with explanations of respiratory muscle activity served to develop awareness of expiratory muscle activity.

Methodology of Part II also focused on expiratory air pressure control, airflow rates, and lung volumes. Air pressure control was taught in three ways: focusing on the feeling in the abdominal muscles that takes place when producing the air pressure necessary to blow up a balloon, observing and manipulating a pressure gauge to study specific air pressures needed to play differing dynamics and pitches on the clarinet (Stone, 1874), and observing diagrams of air pressure changes during clarinet performance compared with air pressure changes during brass and flute performance (Bouhuys, 1964). Airflow rate for expiration was taught by means of exercises designed to reduce airflow impedance, and by examining the relationship between airflow rate to dynamics and pitch. This relationship was examined by timing subjects as they maintained varying pitches for maximal time periods at differing dynamic levels, and observing charts designed to demonstrate that airflow rate increases with increased dynamics (Bouhuys, 1964).

To learn about lung volume changes, subjects attempted to maintain constant airway pressures while blowing into first a closed tube, then an open tube. The closed tube did not allow the escape of air, thus little air volume change in the lungs. While blowing into an open tube, which allowed escape of the air, thus rapidly lowering air volume in the lungs, subjects observed the added difficulty of maintaining pressures at lower lung volumes. Subjects visually observed charts illustrating the relationship of maximal airway pressures to varying lung volumes (Bouhuys, 1964).

Traditional Method of Breath-Management Instruction (TBM). TBM consisted of exercises for strengthening breath-management skills with minimal explanation involved when presenting the exercises. This treatment consisted of exercises for developing controlled inspiration and expiration, accompanied by visual imagery and additional explanation given by the instructor. The premise of TBM was that students should be taught with a psychological approach; that knowledge of the physiological processes involved in breath management does not provide the means for students to develop breath control. TBM was based sequentially on exercises and information from seven woodwind instructional texts: The Art of Saxophone Playing (Teal, 1963), The Art of Woodwind Playing (Weisberg, 1993), The Art of Clarinetistry (Stubbins, 1965), The Teaching of Instrumental Music (Colwell & Goolsby, 1992), The Clarinet and Clarinet Playing (Pino, 1980), The Art of Clarinet Playing (Stein, 1958), and Guide to Teaching Woodwinds (Westphal, 1990). Each of the texts was examined to identify the most prominent instructional strategies relating to breath management. Instructional principles directly relating to breath management appearing in more than 50% of the texts were compiled and incorporated into the instructional methods of the TBM treatment. In addition, exercises based on imagery from these instructional texts were incorporated into the teaching methods of TBM. Inspiratory exercises based on imagery included such exercises as imagining a "slurp of soup" or stepping into a cold shower (Colwell & Goolsby, 1992), and yawning (Teal, 1963; Colwell & Goolsby, 1992). Expiratory exercises included blowing out a candle, hissing like a teakettle (Colwell & Goolsby, 1992), and imagining the air stream to be a violin bow (Teal, 1963; Pino, 1980).

Comparison Group, No Breath-Management Instruction (CBM). CBM received the core instruction in clarinet performance (see pp. 30 - 31) and additional direction on the music they were preparing for performance. In place of breath-management instruction, these subjects received instruction not directly related to breath management, such as direction on notational reading of rhythms and pitches of specific compositions being prepared for concert.

Data Collection and Analysis

To achieve the most accurate, objective method of measuring selected performance variables, the researcher designed a procedure to assess the twelve dependent variables: tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, maximum tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones. To obtain models for constructing the procedures, the researcher surveyed the music research literature and constructed measures used in published experimental studies employing assessments of performance skills associated with breath-management instruction
(Phillips, 1983; Barnes, 1987; Phillips & Vispoel, 1990; Sehmann, 1990; and Phillips & Sehmann, 1990). From this literature the researcher designed a test procedure incorporating specific measuring equipment and procedures to evaluate performance achievement on each of the twelve dependent variables. Explanations of the equipment, measurement tools, and procedures follow.

Equipment

Equipment necessary for measurement procedures included the researcher's Buffet R-13 Bb clarinet, equipped with a Gennusa mouthpiece and a Rico Grand Concert reed size 2.5; a JVC TV-W709 double cassette deck recorder, equipped with an Electro-Voice N/D2578 microphone; a *Visi-pitch* [8]; a stopwatch; a Realistic digital sound-level meter; and a Korg Chromatic Digital Tuner Metronome DTM-12. The Buffet R-13 clarinet was played by subjects for all testing procedures and the audio recorder was used to record all testing sessions for verification of procedures and for evaluation of tone quality. The *Visi-pitch* measured pitch stability and pitch accuracy, the stopwatch measured tonal duration, and the sound-level meter measured dynamic control.

Measurement Tools

To obtain a quantitative measure of tone quality from the audio recordings, two professional clarinetists, acting as independent judges, analyzed the recordings using a researcher-devised form based on a clarinet adjudication form created by Abeles (1973). Using a Likert scale, judges individually assigned a score for perceived tone quality of a researcher-composed exercise that resulted in a composite tone quality score comprised of three areas of measurement: slurred tones (1 through 6), articulated tones (1 through 6), and tone quality as judged without specific consideration of slurred and articulated tones (1 through 6). The resultant composite tone quality measure for each

[8] The *Visi-pitch*, an instrument utilized in the diagnosis and treatment of voice disorders, determines mean frequency of a tone, frequency stability of a tone by calculating the standard deviation of the tone, the length of time that the subject produces the tone, and decibel level of the tone (Prater & Swift, 1984).

judge ranged from 3 to 18, a perfect score. The tone quality measure used for analysis was the mean of the two judges' three scores.

Pitch stability and pitch accuracy of middle and clarion register tones were quantified by use of the *Visi-pitch*, which recorded the frequency of a tone played into the *Visi-pitch* microphone and converted the signal of each production frequency to a Hertz (Hz). To obtain measures most representative of pitch stability and pitch accuracy, the middle four seconds of a six-second sustained tone were isolated for analysis, thus eliminating pitch onset and pitch offset from the recording. For the measurement of pitch stability, the Visi-pitch calculated the standard deviation of the tone, thus determining the dispersion of the pitch. Frequency accuracy was the recorded mean frequency, in Hz, of each tone played into the microphone.

For the measurement of maximum tonal duration, the stopwatch was utilized to measure the maximum duration, in seconds, of each of three tones. The three tones, notated F_3, F_4, and F_5, represented three different ranges of the clarinet–chalumeau, middle, and clarion, respectively.

The sound-level meter was used to measure soft and loud dynamic control of middle and clarion register tones. The mean decibel reading of the middle two seconds of a four-second tone served as the decibel reading of record for extremes of soft and loud tones produced by each subject.

Testing Procedures

The sequence of experimental procedures included a pretest, a treatment period, and a posttest. The pretest and the identical posttest were administered by the researcher individually to all subjects during band and physical education classes (fifth and sixth periods for both schools) of the two weeks prior to implementation of the treatment and the two weeks following completion of the treatment, respectively. During the four weeks of testing, and for purposes of testing individually, many subjects were excused by the school principals and physical education instructors from physical education class as well as band class.

The testing procedure required approximately ten minutes for each subject and included measures of the twelve dependent variables designed to serve as the principal elements of performance achievement–tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones. Detailed descriptions of the testing procedures follow.

The testing order was assigned randomly to avoid potential serial effects because tone quality was evaluated by the same two independent judges for the pre- and posttest. Testing procedures were administered individually in a room equipped specifically for the testing procedures and isolated from the regular classroom. Prior to testing, and to prepare subjects for the test, the researcher explained the testing procedures and the purpose of the *Visi-pitch* and the audio recording equipment.

Although subjects played their own clarinets for individual practice and treatment sessions, subjects performed on the researcher's clarinet (described on p. 36) for all testing to ensure consistency of testing equipment. Each subject was allowed to play the researcher's clarinet for two minutes for purposes of warming up and establishing comfort with the instrument and the mouthpiece and reed combination.

To ensure consistency of testing procedures, subjects were seated with the clarinet bell directed toward a marked area on the floor directly in front and at the center of the subject's chair. The tape recorder and microphone were positioned on a small table and placed directly to the right of the subject's chair. To maintain a controlled dynamic level when performing, the sound-level meter was placed one inch from the bell of the clarinet and the subject was asked to keep the sound-level meter reading at 85 decibels for the duration of the first testing procedure.

Tone Quality. To obtain tone quality measures the researcher audio-recorded each subject performing a researcher-composed etude with subsequent evaluation based on an articulated passage in the etude, a slurred passage in the etude, and overall performance of the etude. Each subject was allowed one minute to study the etude based on music studied previously in the class text (Pearson, 1982). Each subject then attempted to play the musical etude while maintaining a dynamic marking of 85 decibels on the sound-level meter. Two independent judges, a university professor and a doctoral student whose major instrument was clarinet, then evaluated the tone quality of the tape-recorded performance of each subject. For each of the three evaluation areas, judges rated subjects from 1, unacceptable tone quality, to 6, excellent tone quality. For each subject, the three areas of each judge's scores were combined to form a single score for each judge, resulting in extreme composite scores for each judge ranging from 3 to 18 (see Appendix A). The two judges' scores were then averaged, thus forming a single tone quality score for each student. To establish reliability of the two judges' scores, Chronbach's coefficient alpha (Boyle & Radocy, 1987) was computed from the mean and standard deviation of the 38 subjects for each of the two judges.

Pitch Stability of Middle and Clarion Register Tones. To measure the pitch stability of middle register tones, subjects played the notated tone, F_4, into the microphone of the *Visi-pitch* for six seconds at a mezzo forte dynamic marking displayed on the *Visi-pitch*. The *Visi-pitch* isolated the frequency of the middle four seconds of the six-second sustained tone for analysis, and calculated the standard deviation of the middle four seconds of the tone, which served as the pitch stability measure of the notated tone, F_4. The procedure was repeated for the notated clarinet tone, F_5, to measure pitch stability of the clarion register. Each subject was allowed one trial before initiating the tone to ensure an understanding of the procedures.

Pitch Accuracy of Middle and Clarion Register Tones. Pitch accuracy was measured simultaneously with pitch stability by the *Visi-pitch*, which recorded the mean frequency, in Hertz, of the middle four seconds of the sustained notated tone, F_4. The measure for pitch accuracy, for the notated tone, F_4, was the mean Hertz reading of the middle four seconds of the six-second sustained tone. The procedure was repeated for the notated clarinet tone, F_5.

Tonal Duration of Chalumeau, Middle, and Clarion Register Tones. To measure tonal duration of chalumeau, middle, and clarion register tones, subjects were instructed to play representative pitches on the clarinet for as long as possible, while maintaining a sound-level meter reading of 85 decibels, using the A-weighted scale. The researcher held the sound-level meter one inch from the bell of the clarinet and determined that 85 dB was a medium-level sound. First, subjects were instructed to play the notated clarinet tone, F_3, to measure chalumeau tonal duration. The procedure was repeated twice with subjects performing the notated middle register tone, F_4, and finally, the notated clarion register tone, F_5. Duration, in seconds, was measured with a stopwatch from the beginning of each tone to the point where the decibel reading of the sound-level meter, which the researcher held one inch from the bell of the clarinet, dropped below 85 decibels. The three measures were recorded and rounded up to the nearest second.

Soft Dynamic Control of Middle and Clarion Register Tones. To measure soft dynamic control of middle and clarion register tones, intensity measurements were recorded by the sound-level meter using the A-weighted scale. For soft dynamic control of a middle register tone, subjects were instructed to play the notated clarinet tone, F_4, as softly as possible for four seconds. The sound-level meter was held one inch from the bell of the clarinet by the researcher. To eliminate attack and decay, the mean decibel reading of the middle two seconds of the tone and calculated by the sound-level meter served as the decibel reading of record. The procedure of measuring minimum decibels produced by subjects playing a clarion register tone was repeated for clarinet tone, F_5.

Loud Dynamic Control of Middle and Clarion Register Tones. To obtain measures for loud dynamic control of middle and clarion register tones, the procedure for measuring soft dynamic control was repeated with subjects sustaining first the notated tone, F_4, as loudly as possible, for four seconds. The sound-level meter calculated the mean decibel reading of the middle two seconds of the tone which served as the measure of loud dynamic control for the notated clarinet tone, F_4. The subject was then instructed to play the notated tone, F_5, in the same manner, and results were recorded.

Additional Analyses. Additional descriptive analyses were computed on measures of pitch stability, pitch accuracy, and tonal duration. This information served to further justify the use of multiple registers to measure clarinet performance variables, and added descriptive information regarding clarinet performance to the body of literature available to clarinetists.

Control of Contaminating Factors

Some variables specifically identified as likely contaminants include embouchure strength, quality of equipment owned by the subjects, and the amount of time that subjects practiced outside of class. Clarinet embouchure techniques were not taught during any sessions and band directors were requested to eliminate embouchure from their instruction during the course of this study. In addition, no subjects had received any private clarinet instruction. The researcher, therefore, assumed that embouchure of the subjects did not change during the course of the study.

Subject-owned instruments vary in quality; therefore, quality of equipment for the pre- and posttests was controlled by subjects using one clarinet and mouthpiece set-up, including reeds, which were supplied by the researcher. To ensure that all subjects' clarinets and reeds were in satisfactory condition throughout the study, all instruments were inspected by the researcher before the treatment period and necessary repairs were made. Reeds were inspected by the researcher at each session throughout the study to ensure that subjects' clarinets were in satisfactory condition.

To encourage equal practice time, subjects were required to practice 10 minutes nightly on the material assigned in treatment sessions, and parents were requested to sign daily practice reports. Daily assignment sheets were designed by the researcher encouraging practice.

Design and Statistical Analyses

To examine the null hypotheses, 12 one-way univariate analyses of covariance (ANCOVAs) were computed to examine posttest differences by group. Posttest scores of the 12 dependent variables were divided into 12 categories: tone quality, pitch stability of F_4 and F_5, pitch accuracy of F_4 and F_5, tonal duration of F_3, F_4, and F_5; and soft and loud dynamic control of F_4 and F_5. There was one independent variable–instruction, which included three levels of breath management based on physiology, traditional breath management, and a group receiving no breath-management instruction. Twelve one-way ANCOVAs were computed on the posttest data with pretest scores from the 12 dependent variables serving as covariates with their corresponding posttest scores. To determine interscorer reliability of the tone quality evaluations, Chronbach's coefficient alpha (Boyle & Radocy, 1987) was computed on the scores of the two judges. Statistical procedures were computed using the SAS Series in Statistical Applications (1988) at the computing center of the University of North Carolina at Greensboro.

CHAPTER IV

RESULTS

The purpose of the study was to examine the effects of two methods of breath-management instruction on selected performance variables of beginning clarinet students. The question serving as the research objective was: Will method of breath-management instruction–physiology-based (PBM), traditional (TBM), and comparison (CBM)–have an effect on clarinet performance variables of tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones? The twelve null hypotheses for the research question were stated as follows:

1. There is no significant difference between group means of tone quality measurements ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

2. There is no significant difference between group means of pitch stability measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

3. There is no significant difference between group means of pitch stability measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

4. There is no significant difference between group means of pitch accuracy measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

5. There is no significant difference between group means of pitch accuracy measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

6. There is no significant difference between group means of tonal duration measurements of clarinet chalumeau register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

7. There is no significant difference between group means of tonal duration measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

8. There is no significant difference between group means of tonal duration measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

9. There is no significant difference between group means of soft dynamic control measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

10. There is no significant difference between group means of soft dynamic control measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

11. There is no significant difference between group means of loud dynamic control measurements of clarinet middle register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

12. There is no significant difference between group means of loud dynamic control measurements of clarinet clarion register tones ($p \leq .05$) for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction.

To investigate the research objective of treatment effect, group means were examined between three treatment groups on 12 performance skills which were considered to be dependent variables (tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones). Before treatment, three intact classes of sixth-grade clarinet students (N = 38) were divided into three treatment groups (PBM, TBM, and CBM). To determine entry-level group skill differences, a researcher-designed test, measuring the 12 dependent variables, was administered to each of the 38 sixth-grade clarinetists as a pretest. After receiving the respective group instruction, consisting of 13 20-minute class sessions, for a total of 260 minutes of instructional content time over a period of seven weeks, the same test was administered as a posttest.

To determine if there were significant pretest differences between group means, twelve one-way ANOVAs were computed on group mean pretest scores of the twelve dependent variables. A significant difference found between groups on one pretest dependent variable measure justified use of an analysis of covariance. Pearson product-moment correlation coefficients, computed on posttest means of the 12 dependent variables were used to identify the existence, if any, of significant relationships among dependent variables. The lack of significant relationships between posttest means justified univariate analyses.

Therefore, for the main, posttest analysis, 12 one-way univariate ANCOVAs on posttest measures of the 12 dependent variables were computed using corresponding pretest scores as covariates. Statistical procedures were performed by the researcher at the University of North Carolina at Greensboro using the SAS Series in Statistical Applications (1988) packaged computer program. An alpha level was set at .05 for all statistical analyses.

Pretest Data Analysis

Pretest Procedures

A researcher-designed pretest was administered to each subject during the two weeks prior to treatment, the purpose of the pretest being to evaluate pretreatment differences between instructional groups. Testing procedures were designed to measure each of the 12 dependent variables: tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones.

Tone Quality. Evaluation for tone quality was based on an articulated passage, a slurred passage, and overall performance of an etude, as performed by each subject. Composite scores of the three subject areas, for each of two independent judges, were averaged, thus forming a single tone quality score for each subject. To establish reliability of the two judges' scores, Chronbach's coefficient alpha (Boyle & Radocy, 1987) was computed from the mean and standard deviation of the 38 subjects for each of the two judges. Adjudicator 1 consistently scored subjects higher than adjudicator 2, yet there was continuity of the judges' scores, as both adjudicators scored subjects on the same continuum. Interscorer reliability of .87 for the scores of the two independent judges was considered acceptable for pretest tone quality measurement. According to Radocy and Boyle (1988), a reliability coefficient in the .80s is considered acceptable (Table 3).

Table 3

Adjudicators' Pretest Tone Quality Means, Standard Deviations, and Cronbach's Coefficient Alpha Reliability Estimate

Adjudicator	*N*	Mean	SD	Cronbach's Coefficient Reliability
Adjudicator 1	38	13.73	3.19	.87
Adjudicator 2	38	9.44	3.61	

Pitch Stability and Pitch Accuracy of Middle and Clarion Register Tones. Pitch stability and pitch accuracy of middle and clarion register tones were measured by the *Visi-pitch* using the middle four seconds of two six-second sustained tones, F_4, and F_5. The measure for pitch stability for each tone was the standard deviation of the frequency of each tone, as calculated by the *Visi-pitch*, and pitch accuracy was the measured frequency of the notated clarinet tones.

Tonal Duration of Chalumeau, Middle, and Clarion Register Tones. Tonal duration of chalumeau, middle, and clarion register tones was the maximum number of seconds that subjects could maintain representative tones at 85 dB on the sound-level meter, which was considered to be a mezzo forte dynamic marking. Seconds, measured by the researcher, using a stopwatch, were recorded for the notated clarinet tones, F_3, F_4, and F_5.

Soft and Loud Dynamic Control of Middle and Clarion Register Tones. Soft and loud dynamic control of middle and clarion register tones was assessed using intensity measurements as recorded by the sound-level meter. Measures for soft and loud dynamic control of middle and clarion register tones were the mean decibel readings of the middle two seconds of four-second sustained tones played into the sound-level meter. For measures of soft dynamic control, subjects were instructed to play the notated clarinet tones, F_4, and F_5, as softly as possible, and for measures of loud dynamic control, subjects were instructed to play as loudly as possible. The sound-level meter calculated the mean decibel reading of the middle two seconds of the tone which served as the measure for loud dynamic control.

Pretest Analysis and Results

After pretest group means and standard deviations for the 12 dependent variables were calculated between the three groups (see Table 4), 12 one-way ANOVAs were computed on group means of pretest performance measures. As illustrated in Tables 5-16, a significant difference ($p = .02$) was found on only one measure, pitch accuracy, for the clarinet tone F_4 (see Table 8). Tukey multiple comparison tests between PBM and CBM, PBM and TBM, and CBM and TBM revealed that means of both PBM (307.13) and CBM (307.00) performed a significantly higher frequency than the mean for subjects in TBM (304.77) ($p = .01$ and $p = .03$ respectively). Therefore, regarding pitch accuracy, before treatment, the physiology-based group and the control group each performed a significantly higher frequency ($p < .05$), notated clarinet F_4, than the traditional breath-management group. Although no significant differences were found between group means of the remaining 11 scores, indicating that pretreatment groups demonstrated similar entry-level performance abilities on the 11 remaining performance variables tested, analysis of covariance was the procedure of choice because of the

Table 4

Pretest Group Means and Standard Deviations for Performance Measures.

Performance Measures	Groups					
	PBM		TBM		CBM	
	Mean	SD	Mean	SD	Mean	SD
Tone Quality (Score)	12.03	2.82	11.54	3.00	11.00	4.12
Pitch Stability, F_4 (Standard Deviation)	2.07	.59	1.77	.44	2.20	.63
Pitch Stability, F_5 (Standard Deviation)	5.53	1.50	5.15	1.63	5.60	.84
Pitch Accuracy, F_4 (Hertz)	307.13	2.17	304.77	2.31	3.07.00	2.67
Pitch Accuracy, F_5 (Hertz)	614.87	3.64	612.92	4.90	612.60	5.54
Tonal Duration, F_3 (Seconds)	11.27	2.55	12.08	3.07	13.30	4.08
Tonal Duration, F_4 (Seconds)	12.53	4.36	13.85	4.24	14.30	5.08
Tonal Duration, F_5 (Seconds)	10.33	2.94	9.69	5.94	12.00	3.46
Soft Dynamic Control, F_4 (Decibels)	85.27	4.62	87.23	3.39	84.00	2.54
Soft Dynamic Control, F_5 (Decibels)	96.27	7.38	96.23	6.54	94.80	2.53
Loud Dynamic Control, F_4 (Decibels)	97.00	3.63	98.00	2.61	99.00	2.21
Loud Dynamic Control, F_5 (Decibels)	105.47	4.52	104.92	3.71	108.00	4.40

Table 5

ANOVA Summary Table for Pretest Tone Quality Scores

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	6.4635	3.2318	.30	.7400
Error	35	372.464	10.6418		
Total	37	378.9276			

Table 6

ANOVA Summary Table for Pretest Pitch Stability of Notated Clarinet Tone, F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	1.1590	.5795	1.87	.1691
Error	35	10.8410	.3097		
Total	37	12.00			

Table 7

ANOVA Summary Table for Pretest Pitch Stability of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	1.4375	.7188	.36	.7000
Error	35	69.8256	1.9950		
Total	37	71.2632			

Table 8

ANOVA Summary Table for Pretest Pitch Accuracy of Notated Clarinet Tone, F_4

Source	df	Sum of Square	Mean Square	*F*	*p*
Group	2	45.7748	22.8874	4.13	.0246*
Error	35	194.0410	5.5440		
Total	37	239.8158			

* $p < .05$

Table 9

ANOVA Summary Table for Pretest Pitch Accuracy of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	40.0225	20.0113	.92	.4069
Error	35	759.0564	21.6873		
Total	37	799.0789			

Table 10

ANOVA Summary Table for Pretest Tonal Duration of Notated Clarinet Tone, F_3

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	24.8067	12.4034	1.23	.3056
Error	35	353.9564	10.1130		
Total	37	378.7632			

Table 11

ANOVA Summary Table for Pretest Tonai Duration of Notated Clarinet Tone, F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	21.8691	10.9345	.54	.5896
Error	35	713.5256	20.3864		
Total	37	735.3947			

Table 12

ANOVA Summary Table for Pretest Tonal Duration of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	31.2922	15.6461	.84	.4403
Error	35	652.1026	18.6315		
Total	37	683.3947			

Table 13

ANOVA Summary Table for Pretest Soft Dynamic Control of Notated Clarinet Tone, F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	61.8379	30.9190	2.19	.1276
Error	35	495.2410	14.1497		
Total	37	557.0789			

Table 14

ANOVA Summary Table for Pretest Soft Dynamic Control of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	15.5011	7.7505	.20	.8168
Error	35	1332.8410	38.0812		
Total	37	1348.3421			

Table 15

ANOVA Summary Table for Pretest Loud Dynamic Control of Notated Clarinet Tone, F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	24.3421	12.1711	1.37	.2664
Error	35	310.0000	8.8571		
Total	37	334.3421			

Table 16

ANOVA Summary Table for Pretest Loud Dynamic Control of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	59.2383	29.6192	1.66	.2048
Error	35	624.6564	17.8473		
Total	37	683.8947			

difference between groups that was determined for the pitch accuracy measure of F_4.

Posttest Data Analysis

Posttest Procedures

The researcher administered the pretest as a posttest during the two weeks following completion of the treatment. Pretest and posttest procedures were identical, with subjects tested individually during the last two periods of the school day. As with the pretest tone quality scores, after administration of the posttest, Cronbach's coefficient alpha was computed using the evaluators' total tone quality posttest scores. Interscorer reliability of .89 was attained for the scores of the two independent judges and was considered acceptable (see Table 17).

Table 17

Adjudicators' Posttest Means, Standard Deviations, and Cronbach's Coefficient Alpha Reliability Estimate

Adjudicator	*N*	Mean	SD	Cronbach's Coefficient Reliability
Adjudicator 1	38	14.21	3.24	.89
Adjudicator 2	38	9.45	3.50	

Posttest Analysis and Results

To determine whether to implement univariate or multivariate analysis procedures on the posttest data, Pearson product-moment correlations were computed on posttest means of the 12 dependent variables (see Table 18). The highest correlations between performance measures were pitch accuracy

Table 18

Pearson Correlation Summary Table for Posttest Means of Performance Measures

	PSF_4	PSF_5	PAF_4	PAF_5	DF_3	DF_4	DF_5	$SDCF_4$	$SDCF_5$	$LDCF_4$	$LDCF_5$
TQ	-.2822	.0767	.0311	-.0405	.2270	.3760	.3471	.0172	.0167	.1840	.1404
PSF_4		.1293	-.2072	.1364	.0368	-.0629	-.1619	-.0939	-.0493	.1147	.1536
PSF_5			-.3614	-.0876	.1456	.0616	.0419	.0559	-.0012	-.1326	-.1448
PAF_4				.6218	.0498	.0902	.3097	-.1139	-.2174	-.4580	-.4209
PAF_5					.2302	.0463	.2545	-.0806	-.0921	-.3506	-.4358
DF_3						.5900	.6831	-.1811	-.2812	-.1864	.0293
DF_4							.5849	-.2181	-.1512	.0727	.1543
DF_5								.0781	-.2415	-.1409	-.0929
$SDCF_4$									.5663	.0524	-.1602
$SDCF_5$										.0652	.0780
$LDCF_4$											.6603

F_4/pitch accuracy F_5 (.62), duration F_3/duration F_5 (.68), and loud dynamic control F_4/loud dynamic control F_5 (.66) which were considered moderate relationships (J. Penny, personal communication, July 6, 1996), since a strong relationship is .8 and above (Radocy & Boyle, 1988). Any *p* value significance was attributed to Type II error due to small sample size and large standard deviations. Because MANCOVA covaries all pretest scores with all posttest scores, lack of significant relationships among posttest means was an indication that univariate analysis was the appropriate procedure, thus justifying the researcher's decision to compute univariate analyses of posttest means. Therefore, because a significant difference was found between pretest group means of one analysis, justifying the use of analysis of covariance, and because no significant correlations were found between posttest group means, justifying univariate analyses, one-way univariate ANCOVAs were indicated as the most appropriate statistical procedures for comparison of posttest means. Individual posttest scores for the 12 dependent variables were grouped by treatment groups and group means were subjected to 12 one-way ANCOVAs with corresponding pretest measures serving as covariates to control for pretreatment differences. Unadjusted posttest means, standard deviations, adjusted means, and standard errors for the data were calculated and presented below in Table 19. Results of the 12 univariate one-way analyses of covariance are illustrated in Tables 20-31 and the 12 null hypotheses are treated below.

Table 19

Posttest Group Means, Standard Deviations, Adjusted Means, and Standard Error of Performance Measures

		Posttest			
Performance Measures	*N*	Unadjusted Mean	SD	Adjusted Mean	SE
Tone Quality (Score)					
PBM	15	11.73	3.33	11.53	.77
TBM	13	12.12	2.92	12.14	.82
CBM	10	11.60	3.63	11.87	.94
Pitch Stability, F_4, (SD)					
PBM	15	2.27	1.03	2.26	.22
TBM	13	2.00	.71	2.02	.24
CBM	10	2.30	.67	2.28	.28
Pitch Stability, F_5, (SD)					
PBM	15	5.40	1.55	5.37	1.19
TBM	13	5.15	7.11	7.15	1.29
CBM	10	6.60	3.12	6.55	1.46
Pitch Accuracy, F_4, (Hz)					
PBM	15	309.13	1.64	308.83	.44
TBM	13	308.70	2.18	309.23	.49
CBM	10	308.40	1.58	308.15	.53
Pitch Accuracy, F_5, (Hz)					
PBM	15	617.60	4.60	617.20	1.04
TBM	13	615.85	3.08	616.06	1.11
CBM	10	616.80	4.80	617.12	1.27
Total Duration, F_3, (sec.)					
PBM	15	13.00	2.85	13.39	.78
TBM	13	12.15	3.00	12.15	.82
CBM,	10	12.10	4.23	11.51	.96
Tonal Duration, F_4, (sec.)					
PBM	15	14.67	3.27	14.92	.92
TBM	13	13.15	4.39	13.04	.98
CBM	10	13.60	3.24	13.36	1.12
Tonal Duration, F_5, (sec.)					
PBM	15	11.73	3.77	11.81	.78
TBM	13	10.54	2.90	10.83	.84
CBM	10	9.30	3.02	8.81	.97
Soft Dynamic Control, F_4, (dB)					
PBM	15	88.40	4.81	88.55	1.28
TBM	13	85.62	4.09	84.90	1.42
CBM	10	82.00	6.73	82.71	1.61
Soft Dynamic Control, F_5, (dB)					
PBM	15	97.13	6.70	96.95	1.26
TBM	13	95.92	4.13	95.76	1.35
CBM	10	94.10	5.32	94.59	1.55
Loud Dynamic Control, F_4, (dB)					
PBM	15	99.60	4.36	100.00	1.07
TBM	13	98.46	3.15	98.40	1.13
CBM	10	100.50	5.21	99.99	1.32
Loud Dynamic Control, F_5, (dB)					
PBM	15	108.67	4.48	108.87	1.04
TBM	13	108.00	4.58	108.44	1.13
CBM	10	111.30	3.83	110.41	1.31

Research Question

The research question for the study is stated: Will method of breath-management instruction–physiology-based, traditional, and comparison, have an effect on clarinet performance variables of tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones, soft dynamic control of middle and clarion register tones, and loud dynamic control of middle and clarion register tones? The treatment of the twelve null hypotheses follows:

Null Hypothesis 1. There is no significant difference between group means of tone quality measurements for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 20, Null Hypothesis 1 was retained.

Table 20

ANCOVA Summary Table for Posttest Tone Quality Scores

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	2.5506	1.2753	.14	.8662
Error	34	300.5162	8.8387		
Total	37	377.6382			

Null Hypothesis 2. There is no significant difference between group means of pitch stability measurements of clarinet middle register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 21, Null Hypothesis 2 was retained.

Table 21

ANCOVA Summary Table for Posttest Pitch Stability of Notated Clarinet Tone, F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	.4623	.2312	.32	.7316
Error	34	24.9149	.7328		
Total	37	25.7105			

Null Hypothesis 3. There is no significant difference between group means of pitch stability measurements of clarinet clarion register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 22, Null Hypothesis 3 was retained.

Table 22

ANCOVA Summary Table for Posttest Pitch Stability of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	22.7736	11.3868	.53	.5914
Error	34	725.7279	21.3449		
Total	37	751.8158			

Null Hypothesis 4. There is no significant difference between group means of pitch accuracy measurements of clarinet middle register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 23, Null Hypothesis 4 was retained.

Table 23
ANCOVA Summary Table for Posttest Pitch Accuracy of Notated Clarinet Tone , F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	6.008	3.0039	1.10	.3431
Error	34	92.5013	2.7206		
Total	37	120.3158			

Null Hypothesis 5. There is no significant difference between group means of pitch accuracy measurements of clarinet clarion register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 24, Null Hypothesis 5 was retained.

Table 24
ANCOVA Summary Table for Posttest Pitch Accuracy of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	10.2653	5.1327	.32	.7256
Error	34	538.9420	15.8512		
Total	37	638.3158			

Null Hypothesis 6. There is no significant difference between group means of tonal duration measurements of clarinet chalumeau register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 25, Null Hypothesis 6 was retained.

Table 25

ANCOVA Summary Table for Posttest Tonal Duration of Notated Clarinet Tone, F_3

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	21.9434	10.9717	1.25	.3005
Error	34	299.4519	8.8074		
Total	37	389.4737			

Null Hypothesis 7. There is no significant difference between group means of tonal duration measurements of clarinet middle register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 26, Null Hypothesis 7 was retained.

Table 26

ANCOVA Summary Table for Posttest Tonal Duration of Notated Clarinet Tone, F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	27.2918	13.6459	1.10	.3432
Error	34	420.3876	12.3643		
Total	37	492.3421			

Null Hypothesis 8. There is no significant difference between group means of tonal duration measurements of clarinet clarion register tones for sixth-grade clarinetists who received physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 27, Null Hypothesis 8 was retained.

However, the difference approached significance ($p = .067$) for subjects in PBM, who sustained the tone significantly longer than subjects in CBM ($p = .02$) and longer, though not significantly, than subjects in TBM ($p = .40$). There was no difference in duration measures between subjects in TBM and CBM ($p = .13$) although subjects in group TBM sustained the tone longer than subjects in group CBM.

Table 27

ANCOVA Summary Table for Posttest Tonal Duration of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	52.8588	26.4294	2.93	.0672
Error	34	420.3876	12.3643		
Total	37	492.3421			

Null Hypothesis 9. There is a significant difference between group means of soft dynamic control measurements of clarinet middle register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 28, Null Hypothesis 9 was rejected ($p = .0191$). To determine which group means contributed to the significance, Tukey multiple comparison tests were computed comparing the means of PBM and CBM, PBM and TBM, and TBM and CBM. Although there was no significant difference between the means of CBM and TBM ($p = .330$), there was a significant difference ($p = .007$) between group means of CBM and PBM ($p < .01$), and the difference ($p = .066$) between group means of PBM and TBM approached significance at the .05 level. When performing the notated clarinet middle tone, F4, the PBM group performed at a significantly greater intensity level (mean = 89 dB) on soft dynamic control than CBM (mean = 83) and TBM (mean = 85).

Table 28

ANCOVA Summary Table for Posttest Soft Dynamic Control of Notated Clarinet Tone, F4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	218.8803	109.4401	4.46	.0191*
Error	34	834.4540	24.5428		
Total	37	1178.8684			

* $p < .05$

Null Hypothesis 10. There is no significant difference between group means of soft dynamic control measurements of clarinet clarion register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 29, Null Hypothesis 10 was retained.

Table 29

ANCOVA Summary Table for Posttest Soft Dynamic Control of Notated Clarinet Tone, F5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	33.7537	16.8769	.71	.4993
Error	34	809.3867	23.8055		
Total	37	1142.7632			

Null Hypothesis 11. There is no significant difference between group means of loud dynamic control measurements of clarinet middle register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 30, Null Hypothesis 11 was retained.

Table 30
ANCOVA Summary Table for Posttest Loud Dynamic Control of Notated Clarinet Tone, F_4

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	21.5829	10.7915	.65	.5288
Error	34	565.1985	16.6235		
Total	37	653.3947			

Null Hypothesis 12. There is no significant difference between group means of loud dynamic control measurements of clarinet clarion register tones for sixth-grade clarinetists who receive physiology-based, traditional, and no breath-management instruction. Based on the results illustrated in Table 31, Null Hypothesis 12 was retained.

Table 31
ANCOVA Summary Table for Posttest Loud Dynamic Control of Notated Clarinet Tone, F_5

Source	df	Sum of Squares	Mean Square	*F*	*p*
Group	2	21.5015	10.7508	.67	.5201
Error	34	548.4408	16.1306		
Total	37	732.3421			

Additional Analyses

Some descriptive measures, which justified the use of measures from more than one tonal register to represent dependent variables, included pretest mean comparisons of identical measures on tones representing different registers of the clarinet. Repeated measures ANOVAs were computed on overall means between tones from different registers on measures of pitch stability, tonal duration, soft dynamic control, and loud dynamic control. The following is an analysis of the results.

Pitch Stability. As seen in Table 32, the overall mean standard deviation of the sustained frequency F_5 (5.42), used as a measure of pitch stability, was significantly greater (p = .0001) than the standard deviation of F_4 (2.00). For all subjects, there was significantly more frequency variability when producing the clarion register tone than when producing the middle register tone. This could be attributed to unfamiliarity with the clarion register tone, or it may be a natural tendency for young performers of the instrument.

Table 32

Repeated Measures ANOVA Summary Table for Pretest Pitch Stability

Source	df	Sum of Squares	Mean Square	*F*	*p*
Frequency	1	222.3684	222.3684	252.14	.0001
Error	38	32.63158	.8819		
Total	75	305.6316			

Pitch Accuracy. Specific tones and registers of the clarinet have tendencies toward sharpness while others have tendencies toward flatness (Stein, 1959; Stubbins, 1965). Mean pitch accuracy pretest scores for all groups were flat (see Table 4), as the desired frequencies for F_4 and F_5 are 311 Hz and 618 Hz, respectively (Prater & Swift, 1984). All groups improved pitch accuracy from pretest to posttest, and although the improvement was not statistically significant, there was practical significance in the results. The difference in pitch between the overall mean of pretest scores and the overall mean of posttest scores for each tone was detectable to the human ear.

According to Radocy and Boyle (1988), a tone must change a certain number of cents before change is audible to the human ear. The number of cents that a tone of a certain frequency must change is termed the "just noticeable difference" (jnd). According to Stubbins (1965), the average number of cents that a clarinet tone frequency must change before change is audible to the human ear is approximately 4 cents, varying from high to low frequencies. The overall mean frequency for F_4 increased from pretest to posttest by 2.44 Hz, or approximately 13.969 cents (Radocy & Boyle, 1988). Therefore, the overall mean difference in pitch of the F_4 tone improved in pitch accuracy by an amount that should be audible to the human ear. The overall mean pretest frequency score for F_5 increased by 3.29 Hz from pretest to posttest, or approximately 9.42 cents. Therefore, if the jnd is equal to approximately 4 cents, the difference in frequency between pretest and posttest was detectable by the human ear, and the posttest tones might sound more "in tune" to the listener. However, it should be noted, that the difference was not statistically significant.

Tonal Duration. The overall mean scores for posttest duration were F_3 (13.45 sec.), F_4 (12.08 sec.), and F_5 (10.55 sec.). There was a significant duration difference (p = .0001) between these mean frequencies (see Table 33). A Tukey multiple comparison test was computed on the data to determine which frequencies differed significantly. The means of F_3 and F_4 did not differ significantly, yet both F_3 and F_4 had significantly longer duration than F_5. Tones representing the chalumeau and middle registers of the clarinet were sustained significantly longer (p = .0001) than a representative tone from the clarion register of the clarinet.

Table 33

Repeated Measures ANOVA Summary Table for Pretest Tonal Duration

Source	df	Sum of Squares	Mean Square	*F*	*p*
Frequency	2	159.3684	79.6842	10.35	.0001
Error	74	569.9649	7.7022		
Total	113	1956.9211			

Summary

Although there was a statistically significant difference on one performance measure, there was no evidence that method of breath-management instruction as presented in the current study improved performance skills of sixth-grade clarinetists. However, there was observational evidence that physiology-based breath-management instruction affected performance achievement of sixth-grade clarinetists. Although there were no significant differences between groups for measures of tone quality, pitch stability, pitch accuracy, tonal duration, and loud dynamic control measures for subjects who had received physiology-based, traditional, and no breath-management instruction, there was a significant difference between group means on the measure of soft dynamic control, F_4. Subjects who received physiology-based breath-management instruction played with significantly more intensity ($p = .019$) when playing as softly as they could play while maintaining acceptable tone quality, than subjects who received no breath-management instruction, and with more intensity, approaching significance ($p = .067$), than subjects who had received traditional breath-management instruction. Therefore, subjects who had received physiology-based breath-management instruction actually played louder when playing as softly as they could play, than subjects who had received traditional or no breath-management instruction. Additionally, significance was approached on the measure of duration, F_5 ($p = .067$) in that subjects in the PBM group sustained F_5 longer than subjects in CBM ($p = .03$), and longer, though not significantly, than subjects in the TBM group ($p = .14$). There were no significant differences between TBM and CBM groups($p = .40$). Therefore, there was one significant difference between groups and one difference that approached significance, suggesting the possibility that method of breath-management affects performance achievement of sixth-grade clarinetists.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The researcher investigated the effects of two methods of breath-management instruction on selected performance variables of sixth-grade clarinetists across all feasible tonal registers of the clarinet. Breath management was defined as efficient control of the muscles of inspiration and expiration during wind instrument performance. The principal research objective focused on the effects of breath management as associated with performance variables of tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, tonal duration of chalumeau, middle, and clarion register tones; and soft and loud dynamic control of middle and clarion register tones.

Subjects consisted of all beginning sixth-grade clarinet students (N = 38) attending two schools in central North Carolina. Three groups of intact classes of sixth-grade clarinetists were assigned to one of three breath-management groups: physiology-based (PBM, N = 15), traditional (TBM, N = 13), and comparison, no breath-management instruction (CBM, N = 10). Each class was taught by the researcher two or three times a week, on an alternating week schedule. Instruction lasted for a period of seven weeks, consisting of 13 treatment sessions of 20 minutes each, totaling 260 minutes of instruction.

Treatment for the three groups consisted of two components: a core of instructional material covering clarinet performance fundamentals which was identical for each of the three groups, and one of the three instructional approaches: physiology-based breath management, traditional breath management, or no breath management. Core instruction consisted of music preparation, introduction of new notes, chromatic and major scales, hand and finger relaxation and positioning, dynamics, and articulation studies. While all groups were taught the core clarinet technique, the PBM and TBM groups received additional information regarding breath management for clarinet playing. The PBM group was taught breath-management exercises such as correct posture, long tones, inspiratory and expiratory exercises with physiologic explanations, and breathing practices in marked places in the music being studied. PBM also received hands-on investigation of air-pressures and airflow volumes and rates with an air pressure gauge, a water manometer, balloons, and a physiologic doll model. TBM was taught the core curriculum and breath management consisting of correct posture for wind instrument performance, and long tones and breathing exercises without physiologic explanations. CBM was taught a more extensive core curriculum excluding any breath-management instruction.

The 12 measures of clarinet performance achievement were obtained by pretest and posttest measurements. The measure for tone quality was a score determined by combining scores of two independent judges who evaluated audio tape performances of a researcher-designed etude. Quantified measures for pitch stability and pitch accuracy were determined by a *Visi-pitch* instrument. The measure for pitch stability of a middle register tone, notated clarinet tone F_4, was the standard deviation of the middle four seconds of a six-second tone, measured and calculated by the *Visi-pitch*. Pitch stability of a clarion register tone was calculated in the same manner, with subjects playing the notated clarinet tone F_5. For measures of pitch accuracy, the *Visi-pitch* recorded the mean frequency of the same six-second pitch holds. For this measure, the *Visi-pitch* recorded the mean frequency of the middle four seconds of a six-second pitch hold of the middle register clarinet tone, notated F_4, and the clarion register tone, F_5. The recorded measure of pitch accuracy for a middle and a clarion register tone was the mean frequency of each tone.

To measure tonal duration of chalumeau, middle, and clarion register tones, subjects were instructed to play representative pitches on the clarinet for as long as possible, while maintaining a sound-level meter reading of 85 dB, which was considered to be a mezzo forte marking. Duration, in seconds, was measured with a stopwatch from the beginning of each pitch to the point where the decibel reading of the sound-level meter dropped below 85 dB. The researcher recorded maximum duration measurements for each subject performing F_3, F_4. and F_5, each for maximum duration at a decibel reading of 85 dB. The three measures were recorded and rounded up to the nearest second.

To measure soft and loud dynamic control of middle and clarion register tones, intensity measurements were recorded. For soft dynamic control of a middle register tone, subjects were instructed to play the notated clarinet tone, F_4, as softly as possible into a sound-level meter for four seconds, and the mean decibel reading of the middle two seconds of the tone served as the decibel reading of record and was calculated by the sound-level meter. The procedure was repeated for the notated clarinet tone, F_5, to measure minimum decibels produced by subjects playing a clarion register tone. To obtain measures for loud dynamic control of middle and clarion register tones, the procedures were identical with subjects playing as loudly as they could play and still maintain control of the sound.

Data were analyzed by computing 12 one-way univariate analyses of covariance with the 12 performance skills serving as dependent variables and group as the one independent variable. Corresponding pretest measures served as covariates. Analysis of the results indicated that there was a significant effect by group, on the measure of soft dynamic control of the middle register tone, F_4. Measures of tone quality, pitch stability of middle and clarion register tones, pitch accuracy of middle and clarion register tones, soft dynamic control of a clarion register tone, and loud dynamic control of middle and clarion register tones did not produce significant differences by group.

Conclusions

Overview

The current study provided evidence that physiology-based breath-management instruction affects performance skills of sixth-grade clarinetists. Although there were no significant differences on 11 of the 12 measures of dependent variables, evidence exists supporting the possibility that there may be achievement differences as a result of method of breath-management instruction. There was a significant difference between groups in the measure of soft dynamic control, F_4, opposite the direction of expectation–PBM subjects actually played louder than both TBM and CBM subjects when playing as softly as they could play while maintaining acceptable tone quality. Duration, F_5, approached significance ($p = .067$) with PBM subjects achieving a longer playing duration than TBM and CBM subjects. Additionally, this study provided relevant information, not present in the literature, in the following four areas.

1. The effects of method of breath-management instruction.

2. The effects of breath-management instruction on performance skills of clarinetists.

3. Methods for measuring performance skills of clarinetists not previously employed in either published literature or other literature examined by the researcher.

4. Breath-management instruction effects on tones representing more than one register of an instrument.

Five previous studies (Barnes, 1987; Phillips, 1983; Phillips & Sehmann, 1990; Phillips & Vispoel, 1990; Sehmann, 1990) examining performance effects of breath-management instruction have produced conflicting results. Statistical procedures employed to analyze data in these studies varied and could account for some differences in results between the studies.

Statistical design employed in each study may prove an important factor for comparing results among studies. Phillips (1983) computed a MANCOVA, while Phillips and Vispoel (1990) and Sehmann (1990) computed MANCOVA and ANCOVAs. Both Phillips and Vispoel (1990) and Sehmann (1990) were unclear whether ANCOVA analyses consisted of individual univariate ANCOVAs or ANCOVAs utilizing the multiple covariates from the MANCOVA analysis. Barnes (1987) and Phillips and Sehmann (1990) utilized univariate analyses. Barnes (1987) computed ANOVAs on posttest scores, while Phillips and Sehmann (1990) computed only univariate ANCOVAs to analyze data.

Statistics employed in the current study were determined by the lack of significant correlations between dependent measures for the current study. ANCOVAs utilizing multiple covariates may not produce the same results as individual univariate analyses with only one corresponding covariate. In view of this information, results of studies utilizing multivariate applications may not be directly applicable.

A limitation of the current study was the low statistical power due to small sample sizes (PBM = 15, TBM = 13, and CBM = 10) and large standard deviations, thus increasing the risk of Type II error (no significant difference found although a significant difference was present). However, because of the low statistical power of the study there was no need to control for Type I error (a significant difference found although none was actually present).

Tone Quality

There were no significant differences between group means of tone quality measures for subjects who received physiology-based, traditional, and no breath-management instruction. Two possible explanations for the lack of tone quality differences between groups follow:

1. Other performance factors, such as embouchure, may play such an important role in tone quality, that tone quality improvement is masked by the absence of improvement in other vital areas. It is possible that improved breath management without improved embouchure and increased mouthpiece resistance will not improve tone quality.

2. The development of tone quality may be a gradual process which produces audible results over a longer time period, so that results were not perceptible during the time allowed for the study.

Results of other studies conflict (Barnes, 1987; Phillips, 1983; Phillips & Sehmann, 1990; Phillips & Vispoel, 1990; Sehmann, 1990). This study, however, supports results obtained by Barnes (1988), Phillips and Sehmann (1990), and Sehmann (1990). Barnes found no significant differences in vocal quality measures between groups of elementary education majors who received vocal pedagogy instruction including breath management and those who received no vocal pedagogy instruction. Phillips and Sehmann (1990) found no significant differences in tone quality measures between college brass instrument students who had or had not received breath-management instruction. Sehmann (1990) found no significant tone quality differences between elementary-age brass students who had or had not received breath-management instruction.

However, results of this study differ from Phillips and Vispoel (1990), who found a significant difference between posttest means of vocal quality for elementary education majors who had received breath-management instruction and those who had not received breath-management instruction. An additional element in clarinet performance, which may affect performance results, is the embouchure required to produce acceptable tone quality on the clarinet. Embouchure may not be a contaminant in vocal studies.

Conflicting results of studies examining breath-management instruction effects on tone quality are inconclusive. The current study provided no evidence that physiology-based breath-management instruction affects tone quality more than traditional or no breath-management instruction.

Pitch Stability of Middle and Clarion Register Tones

There were no significant differences between group means of pitch stability measures for subjects who received physiology-based, traditional, and no breath-management instruction. Two possible explanations for the lack of significant differences follow:

1. Improved embouchure strength in addition to improved breath management may produce a more stable pitch.

2. The use of judges instead of clinical measuring equipment, which was designed for diagnosis and treatment of speech disorders (Prater & Swift, 1984) may provide a more effective analysis of clarinet tone pitch stability.

The current study is the first music study to measure pitch stability and utilize the *Visi-pitch* to compare tonal stability measures. Measuring pitch stability using the standard deviation calculations of the *Visi-pitch* introduces new potential for future investigations. The ability to sustain a desired frequency on the clarinet is an important goal for many levels of performance, not only beginners. Perhaps, the *Visi-pitch* could serve in training students to maintain stable tones.

The current study provided no evidence that physiology-based breath-management instruction affects pitch stability more than traditional or no breath-management instruction. However, the measurement of pitch stability introduced in this study may aid in future performance research. Although the means were not different between groups, the means of F_5 were larger than the means of F_4 for all three groups, indicating to clarinet performers and teachers that pitch stability is more difficult for clarion register tones than for middle register tones. When learning tones in the clarion register, clarinetists may be more successful in the production of those tones if special attention is focused on breath management and other foundational skills to counter the added difficulty of maintaining pitch stability of the register.

Pitch Accuracy of Middle and Clarion Register Tones

There were no significant differences between group means of pitch accuracy for measurements of subjects who received physiology-based, traditional, and no breath-management instruction. Although there were no statistically significant differences between groups, and although gain scores were not a specific research objective in the study, it may be noted that all groups improved in pitch accuracy. Therefore, some element of the core instruction or maturity may have contributed to subjects' improvement in the direction of the desired frequencies.

Judges' adjudication of audio-taped clarinet performances may have recorded differences that could be regarded as different in terms of practicality and audible to the human ear, yet not statistically significantly different in terms of measured mean frequency. Recording mean frequency with a *Visi-pitch* is an untested area and the highly experimental nature of this study could have contributed to the large standard deviations and the lack of significant differences in results. Measuring the exact mean frequencies of clarinet sustained tones may prove valuable in diagnosing and treating pitch problems with clarinets at various ability levels.

Although results of this study confirm results by Phillips and Vispoel (1990), they are inconsistent with results obtained by Phillips (1983). Phillips and Vispoel (1990) found no significant differences between group means on vocal pitch accuracy measures for college elementary education majors who received breath management and no breath-management instruction. Phillips (1983) found a significant difference in measures of vocal pitch accuracy between posttest means of children who had received breath-management instruction and those who had not received breath-management instruction. However, the definition and measures of pitch accuracy for both Phillips (1983) and Phillips and Vispoel (1990) may not have been comparable to those used in the current study for two reasons:

1. In both studies, judges determined the percentage of tones which were sung accurately in a vocal performance. This measure could be an estimated gross pitch accuracy measure relating to direction and approximate frequency. The current study examined exact frequency of separate, sustained tones, measured by a clinical measuring instrument.

2. The difference of performance idiom may account for differences in results. Phillips was measuring vocal pitch accuracy and the current study measured clarinet pitch accuracy.

Results of previous studies on the effects of breath-management instruction on pitch accuracy are inconclusive. The current study found no evidence that physiology-based breath-management instruction affects pitch accuracy more than traditional or no breath-management instruction. However, the fact that all groups improved in pitch accuracy may be of importance to teachers of young clarinetists and band directors who experience difficulty with the intonation of young players. The subjects in this study performed all pitches flat on the pretest and improved in pitch accuracy on the posttest. Therefore, clarinet teachers may find that added attention given to fundamental principles of clarinet playing, including breath management, may improve intonation of young students.

Tonal Duration of Chalumeau, Middle, and Clarion Register Tones

There were no significant differences between group means of tonal duration for measurements of subjects who received physiology-based, traditional, and no breath-management instruction. Although there were no significant differences between group means, for the measure F_5, group differences approached significance (p = .067), with PBM scoring longer duration than CBM. Low statistical power in the current study may be responsible for the lack of significance in results. Although posttest scores were not significantly different between groups, PBM produced higher scores than both TBM and CBM on all three posttest duration measures while at least one tone measured shorter duration on posttest scores for both TBM and CBM. Perhaps, longer treatment period would have resulted in significant result differences between groups.

As with measures of tone quality and pitch accuracy, results from previous studies conflict. The current study supports findings by Phillips and Vispoel (1990), and Phillips and Sehmann (1990). Phillips and Vispoel (1990) found no significant differences between group means of vocal tonal duration for measurements of elementary education majors who received breath-management instruction and those who received no breath-management instruction, and Phillips and Sehmann (1990) found no significant differences between group means of tonal duration for measurements of brass students who received breath-management instruction and those who received no breath-management instruction. Results from the current study do not support results by Sehmann (1990), who found significant tonal duration differences between brass students who had received breath-management instruction and those who had not received breath-management instruction.

Phillips (1983) reported results opposite the direction of training in that subjects who had received breath-management instruction performed significantly fewer seconds on posttest measures of vocal duration, than did subjects who had received no breath-management instruction. Phillips suggested that if students were using more air to produce improved vocal intensity, the duration might decrease. In the current study, duration increased, though not significantly, thus neither supporting nor refuting Phillips' finding.

Effects of breath-management instruction on measures of tonal duration have been examined by Phillips (1990), Phillips and Sehmann (1990), Phillips and Vispoel (1990), and Sehmann (1990) with conflicting results. Results of the current study, although not significantly different between groups or from method of instruction, suggest that physiology-based breath-management instruction may affect tonal duration more than no breath-management instruction. Therefore, instructors may find that instruction in the physiology of breath management may benefit tonal duration of beginning clarinet students.

Soft Dynamic Control of Middle and Clarion Register Tones

There was a significant difference between group means of soft dynamic control measures of clarinet middle register tones for sixth-grade clarinetists who received physiology-based, traditional, and no breath-management instruction. The mean decibel reading for PBM was significantly greater than the mean decibel reading for TBM ($p = .01$), and the difference between TBM and PBM approached significance ($p = .066$) with PBM measuring greater decibels than TBM. There were no significant differences between group means of TBM and CBM. Perhaps breath-management instruction, encouraging PBM subjects to support the tone throughout soft tones, resulted in a greater intensity level tone for PBM subjects than for subjects who had not received PBM instruction. Thus, subjects who had received PBM instruction actually played louder when instructed to play as softly as they could play, opposite the direction of expectation, than subjects who had not received PBM instruction. It is possible that supporting the tone results in soft tones performed at greater intensity, especially as students are learning to support tones.

However, there was no significant difference between group means of soft dynamic control measures of clarinet clarion register tones for sixth-grade clarinetists who received physiology-based, traditional, and no breath-management instruction. The researcher had to teach the notated tone, F_5, to subjects because the classes had not yet learned it. Since F_5 was new to the subjects at the time of the pretest, they had not yet played it in class or performed the tone as much as the notated tone, F_4. Unfamiliarity with the new note may account for the lack of significant difference in group means.

The current study provides evidence that physiology-based breath-management instruction does affect soft dynamic control of sixth-grade clarinetists more than traditional or no breath-management instruction. However, clarinetists who received physiology-based breath-management instruction played with significantly more intensity when playing as softly as they could play while maintaining acceptable tone quality, than clarinetists who received traditional or no breath-management instruction. Therefore, teachers should be aware that young clarinetists who are taught breath management may, at the beginning stages of breath management development, play louder when physically and psychologically attempting to play softly than students who are not taught breath management. Thus, according to the results of the current study, teachers should allow students to play as softly as possible while focusing on breath management, never requiring students to sacrifice breath support to obtain softer dynamics. Breath support, therefore, should be a priority during the performance of soft dynamics.

Loud Dynamic Control of Middle and Clarion Register Tones.

There were no significant differences between group means of loud dynamic control measures of clarinet middle and clarion register tones for sixth-grade clarinetists who received physiology-based, traditional, and no breath-management instruction. Although gain scores were not identified by a specific research objective, it may be noted that all three groups played louder (not significantly) on posttest measures than on pretest measures for both tones. For the measure of F_4, the pretest/posttest mean gain score was greater for subjects in the PBM group (up 2.6 dB), than the TBM group (up .46 dB) and the CBM group (up 1.5 dB), indicating that young students may benefit from physiology-based breath-management instruction in areas of loud dynamic control. For the measure of F_5, all three groups increased decibels more than they did for F_4. Because all three groups--PBM (up 3.2 dB), TBM (up 3.08 dB), and CBM (up 3.3 dB)--improved tonal duration, F_5, it is possible that maturity or something taught in the core part of the treatment could account for the improvement. However, it is possible that improvement in breath management alone is not sufficient to improve loud dynamic control significantly without simultaneous improvement in embouchure strength or some other factor of control.

These results are inconsistent with Phillips (1983) who found significant differences between group means of vocal intensity measures of children who had received breath-management instruction and those who had not. Although elementary-age children sang with significantly greater intensity after breath-management instruction than did children who had not received breath-management instruction (Phillips, 1983), the middle school age clarinetists in this study who had received breath-management instruction did not play selected tones significantly louder than students who had received no breath-management instruction when playing as loudly as they could play while maintaining control of the sound. Although loud dynamic control measures were not significantly different between groups, there is evidence to suggest that taking the time to learn and teach physiology-based breath management may benefit some teachers by improving the efficiency of their teaching.

Summary

Existing research has examined the effects of breath management on performance variables of tone quality, pitch accuracy, tonal duration, and loud dynamic control with conflicting results. In the current study, a teaching method to instruct subjects regarding the physiologic aspects of clarinet performance was constructed and tested. The current study adds to the research and information available to musicians regarding method of breath-management instruction on tone quality, pitch stability of tones in two registers, pitch accuracy of tones in two registers, tonal duration of tones in three registers, soft dynamic control of tones in two registers, and loud dynamic control of tones in two registers. Based on the results of this study, the researcher must conclude that, although physiology-based instruction may affect performance skills of sixth-grade clarinetists, there were no significant differences between groups to confirm that physiology-based breath-management instruction improves clarinet performance achievement, as measured, more than traditional or no breath-management instruction. However, because of conflicting results in previous studies and in the current study, it is recommended that more research be conducted in this area.

General Observations

During the course of the study the researcher made several observations. The researcher observed a positive attitude change in the PBM group and in the band director of the breath-management groups over the course of the instruction period. It appeared to the researcher that the group who received physiologic instruction was more enthusiastic about practicing the assigned material than the group who received traditional breath-management instruction. Perhaps, with a longer treatment time period, or with more sophisticated testing equipment, results would be different.

The band director of the breath-management groups demonstrated enthusiasm about the instruction because of the improvement he subjectively observed in the students' attitudes and performances. Although there were no significant differences among groups in pitch accuracy, the band director of the breath-management groups subjectively observed improvement in the intonation of the clarinetists. No data were gathered on student retention in the band program; however, one year after the completion of the study, the band director of the breath-management groups reported that retention rate of the clarinetists who had participated in the study appeared to be greater than for clarinetists from other years in his program.

The researcher observed that breath management appears to be a complex task that may require skill development over time. Breath management may be so interdependent with embouchure strength that breath management alone may not produce significant differences between individuals. Embouchure strength development, simultaneously with breath management development, may result in desired performance quality that breath management alone cannot accomplish.

Beginning clarinetists may benefit from the knowledge that there are performance skill goals beyond simply learning the correct fingering and that those skills can be accomplished with dedicated practice on basic skill development. Hopefully, interest was created in subjects to further their clarinet study, such as in private lessons, to accomplish these goals.

Finally, teaching students a physiology-based approach to playing the clarinet may have stimulated some students' interest in clarinet performance techniques as well as in research, science, and human physiology. With a pragmatic approach making science class relevant to clarinet performance, hopefully, students will begin to think critically about their own clarinet performance.

Recommendations for Additional Research

Several recommendations for future research originated from this study. The current study should be repeated with larger groups and for a longer period of time. For example, it is recommended that separate beginner classes be taught for an entire year by respective band directors placing emphasis on either physiology-based or traditional breath-management instruction.

The feasibility of using standardized measuring tools, such as the *Visi-pitch*, should be investigated and the usefulness of these applications in pedagogy should be studied. It would be interesting to correlate measurements of pitch stability from judges' evaluations of audio-taped performances and standard deviations calculated by the *Visi-pitch* to determine which measure is a more practical and valid method of measuring pitch stability.

Attitudes of subjects who have participated in breath-management instruction should be assessed. Pretest and posttest attitudes toward the practice of breath-management exercises between subjects who have been instructed in breath management techniques and those who have experienced either traditional or no breath-management instruction should be compared.

Descriptive data on professional clarinetists could generate information regarding actual differences and similarities among pedagogical philosophies. For both student and professional clarinetists, further information regarding airflow rates, airway pressures, pitch stability, pitch accuracy, and soft and loud dynamic control across different registers of the clarinet should be measured and compared.

The development of new pedagogical techniques and the refinement of traditional techniques may be advanced by the investigation of objective and scientific information regarding physiological performance. Scientists and musicians working together to advance an understanding of musical performance may introduce a new era of musical pedagogy and performance.

BIBLIOGRAPHY

Abeles, H. F. (1973). Development and validation of a clarinet performance adjudication scale. Journal of Research in Music Education, 21 (3), 246-255.

Akgün, N., & Özgönül, H. (1967). Lung volumes in wind instrument (zurna) players. American Review of Respiratory Disease, 96, 946-951.

Anastasio, A., & Bussard, N. (1971). Mouth air pressure and intensity profiles of the oboe. Journal of Research in Music Education, 19, 62-76.

Anfinson, R. (1965). A cineflourographic investigation of supralaryngeal adjustments in selected clarinet playing techniques. Unpublished doctoral dissertation, State University of Iowa, Iowa City.

Barnes, S. (1987). The effect of class voice instruction and differential song material on vocal performance, vocal knowledge, and attitude of elementary education majors. Unpublished doctoral dissertation, The Ohio State University.

Barton, E., & Laws, S. (1902). Air pressures used in playing brass instruments. Philosophical Magazine and Journal of Science, 3 (Series 6), 385-393.

Benade, A. (1986). Interactions between the player's windway and the air column of a musical instrument. Cleveland Clinic Quarterly, 53(1), 27-32.

Benade, A., & Gans, D. (1968). Sound production in wind instruments. Annals of the New York Academy of Science, 155, 247-263.

Berger, K. (1965). Respiratory and articulatory factors in wind instrument performance. Journal of Applied Physiology, 20, 1217-1221.

Berger, K. (1968). Electromyographic recording during wind instrument performance. Annals of the New York Academy of Science, 155, 297-302.

Berger, K., & Hoshiko, M. (1964). Respiratory muscle action of trumpet players. Instrumentalist, 19, 91-94.

Borden, G., & Harris, K. (1984). Speech science primer (2nd ed.). Baltimore: Williams & Wilkins.

Borgia, J., Horvath, S., Dunn, F., Von Phul, P., &Nizet, P. (1975). Some physiological observations in French horn musicians. Journal of Occupational Medicine, 17, 696-701.

Boschma, H. (1989). Breathing. Brass Bulletin, 66, 40-41.

Bouhuys, A. (1962). Breathing and blowing. Sonorun Speculorum, 13, 107.

Bouhuys, A. (1964). Lung volumes and breathing patterns in wind-instrument players. Journal of Applied Physiology, 19, 967-975.

Bouhuys, A. (1968). Pressure-flow events during wind instrument playing. Annals of the New York Academy of Science, 155, 264-274.

Bouhuys, A. (1969). Physiology and musical instruments. Nature, 221, 1199-1204.

Bouhuys, A. (1974). Breathing: Physiology, environment, and lung disease. New York: Grune & Stratton.

Bouhuys, A. (1977). The physiology of breathing. London: Grune & Stratton.

Bouhuys, A. (1983). Pressure-flow events during wind instrument playing. International Trumpet Guild Journal, 7(3), 11-18.

Bouhuys, A., Proctor, D., & Mead, J. (1966). Kinetic aspects of singing. Journal of Applied Physiology, 21, 483.

Boyle, D., & Radocy, R. (1987). Measurement and Evaluation of Musical Experiences. London: Schirmer.

Campbell, D. & Stanley, J. (1963). Experimental and quasiexperimental designs for research. Boston: Houghton & Miifflin.

Campbell, E. (1958). The respiratory muscles and the mechanics of breathing. London: Lloyd-Luke.

Campbell, M., & Greated, C. (1987). The musician's guide to acoustics. New York: Schirmer.

Carter, W. (1966). The role of the glottis in brass playing. Instrumentalist, 221 (5), 75-79.

Cherniack, R., Cherniak, L., & Naimarck, A. (1972). Respiration in health and disease. Philadelphia: Saunders.

Colwell, R. (Ed.). (1992). Handbook of research on music teaching and learning. New York: Schirmer.

Colwell, R., & Goolsby, T. (1992). The teaching of instrumental music (3rd ed.). London: Prentice-Hall.

Cook, C., & Mead, J., & Orzalesi. (1964). Static volume-pressure characteristics of the respiratory system during maximal efforts. Journal of Applied Physiology, 19(5), 1016-1022.

Cramer, W. (1981). Blowing as a body function. Brass Bulletin, 34, 29-36.

Cramer, W. (1985). Valsalva maneuver-why? Brass Bulletin, 52, 36-8.

Cugell, D. (1986). Interaction of chest wall and abdominal muscles in wind instrument players. Cleveland Clinic Quarterly, 53(1), 15-20.

Dawley, R., (1985). Medical research in music: Foundations for a theory of music instruction. Bulletin of the Council for Research in Music Education, 85(1), 38-55.

Dennis, R. (1987). Musical performance and respiratory function in wind instrumentalists: Effects of the Alexander technique of musculoskeletal education. Unpublished doctoral dissertation, Columbia University Teachers College, New York.

Dick, R. (1987). Circular breathing-you can do it. Instrumentalist, 41(7) 62-68.

Erb, R. (1987). Arnold Jacobs legacy. Instrumentalist, 41(9), 22-24, 82, 84-88.

von Euler, C. (1968). The proprioceptive control of the diaphragm. Annals of the New York Academy of Sciences, 155, 204-205.

Farkas, P. (1986). Medical problems of wind players: A musician's perspective. Cleveland Clinic Quarterly, 53(1), 33-38.

Faulkner, M., & Sharpey-Schafer, E. (1959). Circulatory effects of trumpet playing. British Medical Journal, 1, 685-686.

Faulkner, M. (1967). Experimentation in breathing as it relates to brass performance. Instrumentalist, 21(6), 6-7.

Faulkner, M. (1983). Continuous air flow in Australia. Instrumentalist, 37(9), 8.

Fenn, W., Bouhuys, A., & Craig, A. (1964, July). Some physiological principles of interest to wind instrument players. In W. O. Fenn (Chair), The Physiology of Breathing for Woodwind and Brass Instruments. Seminar conducted by the Eastman School of Music, Rochester, NY.

Frucht, A. (1937). Zur physiologie des blasinstrumentenspiels. Pfluger's Archiv Fur Die Gesante Physiologie, 239, 419-429.

Gibson, L. (1992). Claranalysis: Tonal formants in clarinets. Clarinet, 19(4), 16.

Goddard, R. (1990). An investigation of two clarinet tonguing techniques. Bulletin of the Council for Research in Music Education, 104, 49-53.

Guyton, A. (1976). Textbook of medical physiology. Philadelphia: W.B. Saunders.

Hanson, F. (1967). Control of staccato sound production by laryngeal muscles. Journal of Band Research, 4(1), 61-64.

Hasselmann, R. (1987). Arnold Jacobs legacy. Instrumentalist, 41(8), 16-17.

Heaton, W., & Hardens, C. (Eds.). (1958). An interdisciplinary index of studies in physics, medicine, and music related to the human voice. Bryn Mawr, PA: Theodore Presser.

Horvath, S., & Faulkner, M. (1980). Physiological observations on French horn players. Instrumentalist, 35(3), 72-80.

Huttlin, E. (1982). A study of lung capacities in wind instrumentalists and vocalists. Unpublished doctoral dissertation, Michigan State University, East Lansing, MI.

Johnson, K. (1990). Good respiratory practices for brass performers. Journal of the International Trumpet Guild, 14(4), 57, 60.

Keathley, G. (1975). The Keathley spirometer as a teaching tool. National Association of College Wind and Percussion Instructors, 24(1), 9-13.

Keene, J. (1969). Some physiological aspects of playing instruments. Instrumentalist, 24(3), 80-84.

Kelly, K. (1983). The dynamics of breathing with Arnold Jacobs and David Cugell, M.D. Instrumentalist, 38(5), 6-12.

Kendall, M. (1988). Two instructional approaches to the development of aural and instrumental performance skills. Journal of Research in Music Education, 36, 205-219.

Kennan, K. (1970). The technique of orchestration (second edition). Englewood Cliffs, NJ: Prentice-Hall.

Kohut, D. (1985). Musical performance: Learning theory and pedagogy. Englewod Cliffs, NJ: Prentice-Hall.

Konno, K., & Mead, J. (1967). Measurement of the separate volume changes of rib cage and abdomen during breathing. Journal of Applied Physiology, 22, 407-422.

Lederman, R., & Brandfonbrener, A. (1986). Medical problems of musicians: Introduction and overview. Cleveland Clinic Quarterly, 53(1), 1-2.

Lockwood, A. (1989). Medical problems of musicians. New England Journal of Medicine, 320(4), 221-7.

Levine, H. (1986). Functional disorders of the upper airway associated with playing wind instruments. Cleveland Clinic Quarterly, 53(1), 3-10.

Malave, J. (1991). A computer-assisted aural-visual approach to improve beginning students' clarinet tone quality (Doctoral dissertation, University of Texas, Austin). Dissertation Abstracts International, A51 (10), 3355, DA9105609.

Maxwell, A., Burdon, I., & Macdonald, S. (1964). Faber's anatomical atlas (rev. ed.). London: Faber and Faber.

McDowell, A. (1966). Are we teaching the clarinet properly? Instrumentalist, 221(5), 73-74.

Mead, J., Bouhuys, A., & Proctor, D. (1968). Mechanisms generating subglottic pressure. Annals of the New York Academy of Sciences, 155, 177-181.

Mellott, G. (1975). Whistling for high-notes focus on the clarinet. National Association of College Wind and Percussion Instructors, 23(3), 43.

Mellott, G. (1975). Keys to correct breathing for the woodwind player. National Association of College Wind and Percussion Instructors, 24(2), 42-44.

Merriman, L. (1978). Woodwind research guide. Evanston, IL: Instrumentalist.

Middleton, J. (1975). A matrix for instrumental competencies. Missouri Journal of Research in Music, 3(4), 40-43.

Miller, R. (1986). The structure of singing. London: Schirmer.

Morris, J., Kosk, A., & Johnson, L. Spirometric standards for healthy nonsmoking adults. American Review of Respiratory Disease, 103, 57-67. (1971).

Navrátil, M., & Rejsek, K. (1968). Lung function in wind instrument players and glassblowers. Annals of the New York Academy of Sciences, 155, 276-283.

Pearson, B. (1982). Best in class. San Diego, CA: Kjos.

Perone, K. (1989). Listing of American doctoral dissertations for the clarinet, part 1. Clarinet, 17(1), 58-62.

Perone, K. (1990). Listing of American doctoral dissertations for the clarinet, part 2. Clarinet, 17(2), 39-43.

Phillips, K. (1983). The effects of group breath control training on selected vocal measures related to the singing ability of elementary students in grades two, three. Unpublished doctoral dissertation, Kent State University, Kent, OH.

Phillips, K. (1992). Research on the teaching of singing. In R. Colwell (Ed.), Handbook of Research on Music Teaching and Learning (pp. 568-576). New York: Macmillan.

Phillips, K., & Sehmann, K. (1990). A study of the effects of breath management instruction on the breathing mode, knowledge of breathing, and performance skills of college-level brass players. Bulletin of the Council for Research in Music Education, 105(4), 58-71.

Phillips, K., & Vispoel, W. (1990). The effects of class voice and respiration instruction on vocal knowledge, attitudes, and vocal performance among elementary education majors. Quarterly, I (1 & 2), 96-105.

Pino, D. (1980). The clarinet and clarinet playing. USA: Berne Convention.

Prater, R., & Swift, R. (1984). Manual of voice therapy. Austin: Pro-ed.

Pyne, J. (1985). In search of resonance: Some preliminary findings. Clarinet, 12(3), 30-33.

Radocy, R., & Boyle, J. (1988). Psychological foundations of musical behavior. Springfield, IL: Charles C. Thomas:

Rainbow, E. (1973). Instrumental music: Recent research and considerations for future investigation. Bulletin of the Council for Research in Music Education, 33, 8-20.

Robinson, J. (1987). Oboists, exhale before playing. Instrumentalist, 41(10), 23-27.

Roos, J. (1936). The physiology of playing the flute. Archives Neerlandaises de Phonetique Experimentale, 12, l-26.

Roos, J. (1938). The physiology of playing the flute. (2nd communication). The flageolet tones. Archives Neerlandaises de Phonetique Experimentale, 14, 49-57.

Roos, J. (1940). The physiology of playing the oboe. Archives Neerlandaises de Phonetique Experimentale, 16, 137-153.

Russo, W. (1973). An interview with Arnold Jacobs. Instrumentalist, 27 (7), 28-30.

SAS Institute Inc. SAS/STAT ® User's Guide (Release 6.03 Ed.). Cary, NC: SAS Institute Inc., 1988. 1028.

Schorr-Lesnick, B. (1988). Lung function and health attitudes and habits in professional wind musicians and vocalists. The Mount Sinai Journal of Medicine, 55, 346-352.

Schwartz, R. (1989). Breath support: The enigma. National Association of College Wind and Percussion Instructors Journal, 37(4), 45.

Sehmann, K. (1990). The effects of breath management instruction on the performance of elementary brass players. Unpublished doctoral dissertation, The University of Iowa, Iowa City.

Smith, J., Kreisman, H., Colacone, A., Fox, J., & Wolkove, N. (1990). Sensation of inspired volumes and pressures in professional wind instrument players. Journal of Applied Physiology, 68, 2380-3.

Stauffer, D. (1968). Physical performance, selection, and training of wind instrument players. Annals of the New York Academy of Sciences, 155, 284-289.

Stewart, M. (1987). Arnold Jacobs: The legacy of a master. Evanston, IL: Instrumentalist.

Stone, W. (1874). On wind-pressure in the human lungs during performance on wind instruments. Philosophical Magazine and Journal of Science, 48, 113-114.

Stein, K. (1958). Art of clarinet playing. Evanston: Summy-Birchard.

Stubbins, W. (1965). Art of clarinetistry. Ann Arbor, MI: Ann Arbor Publishing.

Sundberg, J. (1987). The science of the singing voice. Dekalb, IL: Northern Illinois University Press.

Sundberg, J., Leanderson, C., von Euler, C., & Lagercrants, H. (1983). Activation of the diaphragm in singing. In Proc. of Stockholm Music Acoustics Conference 1983 (pp. 279-90). (SMAC 83) (1) ed. A Askenfelt, S. Felicetti, E. Jansson, and J. Sundberg, 279-90. Stockholm: Royal Swedish Academy of Music.

Taylor, R. (1968). A study of the concepts of breathing as presented in literature dealing with tone production for orchestral brass-wind instruments. Doctoral dissertation, Columbia Teachers College, New York.

Teal, L. (1963). Art of saxophone playing. Evanston, IL: Summy-Birchard.

Tucker, A., Faulkner, M. & Horvath, S. (1971). Electrocardiography and lung function in brass instrument players. Archives of Environmental Health, 23, 327-332.

Turrentine, E. (1977). The physiological aspect of brass-wind performance technique: A bibliographic essay. National Association of College Wind and Percussion Instructors, 26 (2), 3-5.

VanMiddlesworth, J. (1978). An analysis of selected respiratory and cardiovascular characteristics of wind instrument performers. Unpublished master's thesis, Eastman School of Music, Rochester, NY.

VanMiddlesworth, J. (1993). A descriptive analysis of wind instrument performance physiology: Selected respiratory and cardiovascular characteristics of wind instrument performers. In J. A. Braswell (Ed.), Proceedings of the 1993 Southeastern Music Education Symposium. Athens: University of Georgia.

Vax, M. (1976). Correct breathing for all wind instruments. Crescendo International, 14, 31.

Vivona, P. (1968). Mouth pressures in trombone players. Annals of the New York Academy of Sciences, 155, 290-296.

Wade, O. (1954). Movements of the thoracic cage and diaphragm in respiration. Journal of Physiology, 124, 193-212.

Walker, K. (1989). Teaching young flutists breath control. Instrumentalist, 43(6), 56-61.

Weerts, R. (1992). Research on the teaching of instrumental music. In R. Colwell (Ed.), Handbook of Research on Music Teaching and Learning (pp.577-583). New York: Macmillan.

West, J. (1974). Respiratory physiology--the essentials. Baltimore: Williams & Williams.

Weisberg. (1993). The art of woodwind playing. New York: Schirmer.

Westphal, F. (1990) Guide to teaching woodwinds. Sacramento: W.C. Brown.

de Wetter-Smith, B. (1978). Breath control and tone refinement. Instrumentalist, 32, 83-84.

Wheeler, R. (1977). New technology refutes old techniques. Instrumentalist, 32(2), 66-70.

Wilson, F. & Roehmann, F. (1992). The study of biomechanical and physiological processes in relation to musical performance. In R. Colwell (Ed.), Handbook of Research on Music Teaching and Learning (pp. 509-523). New York: Macmillan.

Wilson, H. (1993). The thoracoabdominal diaphragm. Clarinet, 20(3), 22-25.

Wilson, T. (1984). Wind and Voice. Dublin, Ireland: Minim Books.

APPENDIX A

EVALUATION FORMS:

EVALUATION FORM I: TONE QUALITY

EVALUATION FORM II: PITCH STABILITY, PITCH ACCURACY, TONAL DURATION, AND DYNAMIC CONTROL

SAMPLE PERMISSION FORM:
PRINCIPAL'S PERMISSION FORM

EVALUATION FORM I: TONE QUALITY

Student #__________

Please evaluate the students with the degree that you agree or disagree with the statement. Evaluate students according to how you believe a sixth-grade sound should be.

	strongly disagree					strongly agree
I. The student exhibits excellent tone quality in the slurred passages.	1	2	3	4	5	6
II. The student exhibits excellent tone quality in the articulated passages.	1	2	3	4	5	6
III. The student exhibits excellent overall tone quality.	1	2	3	4	5	6

Total score:___

EVALUATION FORM II: PITCH STABILITY, PITCH ACCURACY, TONAL DURATION, AND DYNAMIC CONTROL

Student # _________

	G_3	G_4	G_5

I. PITCH STABILITY

sd of Hz _____ sd of Hz ____ sd of Hz ____

II. PITCH ACCURACY

mean Hz _____ mean Hz ____ mean Hz ____

mean dB _____ mean dB ____ mean dB ____

III. TONAL DURATION AT MEZZO FORTE

_____ sec. ____ sec. ____ sec.

IV. DYNAMIC CONTROL

<u>pianissimo</u>

min. dB _____ min. dB ____ min. dB ____

<u>fortissimo</u>

max. dB _____ max. dB ____ max. dB ____

February 14, 1994

Mr. James Kiger, Principal
Brown Middle School
1140 Kendall Mill Road
Thomasville, NC 24360

Dear Mr. Kiger: :

I am requesting permission to conduct a research study using all sixth and seventh grade clarinetists of the Brown Middle School Band program. Because of my experience as a music teacher, I am interested in determining how music instruction can be modified to better meet the needs of middle school students. I am particularly interested in working with the students at your school because, as a music consultant for the clarinets, hired by Mr. Kiefer of East Davidson High School in the fall of 1994, I feel that I understand the goals and needs of your students. As a Ph.D.. student at The University of North Carolina at Greensboro, my work with clarinet students has reinforced my awareness of the need for more effective teaching methods. I will be examining the effects of method of breath-management training on clarinet performance. Although results of this research will be published in my doctoral dissertation, confidentiality will be maintained and no identification of students or school will occur.

The study would proceed for ten weeks, beginning Monday, February 28, 1994 and continuing through Friday, May 13, 1994. During this time I will be teaching breath-management skills for clarinet performance to small groups of students. No monetary expense will be incurred by the students and there will be no risks to the children. To receive the full benefits of the instruction, students will be asked to practice assigned material each evening, and parents are asked to send signed practice records to school. Prior to beginning the study, written parental consent to participate in the study would be obtained for all students. Additionally, students successfully completing the program would receive a free pizza party.

I feel confident that this experience would benefit your students and enhance the excellent education that your band program already provides. The study would provide students with opportunities for small group, specialized clarinet instruction which would enhance their enjoyment of the music program. In addition, it will support the music program in your school. I appreciate your assistance and consideration of my request. I look forward to hearing from you soon (910-854-9552, home; 910-334-5435, office). Best wishes.

Sincerely,

Jane VanMiddlesworth

cc: David Deese

APPENDIX B

TECHNIQUES USED IN INSTRUCTION

TECHNIQUES USED IN INSTRUCTION

The following are examples of exercises and lesson plans for the three methods utilized during the treatments. A sample lesson plan is included for the first lesson in the physiologic method.

Treatment 1: Physiologic Method

Exercises for the physiologic method of breath-management instruction were divided into three areas; exercises designed for introduction and preparation, exercises of inspiration, and exercises of expiration. The first set of exercises were designed to introduce students to the concepts that breathing to play wind instruments is different from normal, at rest breathing. Exercises designed to improve posture, reduce restrictions in the airway passages, and initiate the desire for further study in this area prepared the subjects for the remaining treatment sessions. The body of the treatment sessions included exercises to develop and improve inspiratory and expiratory functions, including the study of lung volume changes, air flow, and air pressures. To introduce these concepts to the subjects, diagrams, x-rays, scientific models of the body and the lungs, a slinky, and a water manometer were utilized.

Exercises of Inspiration; Lessons 2 - 4

Exercises of inspiration were designed to facilitate understanding of the actions of the respiratory muscles during inspiration, elastic properties of the lungs, and relaxed, unrestricted airways.

Respiratory Muscles

1. Subjects were instructed to Inhale quickly and deeply with the tongue in an "ah" position. Visual representations of the airway passages (Sundberg, 1990; model of the lungs, anatomical doll) reinforced the concept of unrestricted vocal folds and full descent of the diaphragm. Subjects repeated the exercise inhaling for a period of two and four seconds, respectively.

2. Subjects were instructed to lean forward while sitting in a chair with the left hand placed against the side of the body, below the waist. Subjects were instructed to inhale four counts, then exhale four counts while hissing a consonant, "s." The exercise was repeated in an upright position with the left hand remaining against the left side while subjects attempted to reproduce the sensation of the abdominal muscles relaxing against the hand to allow room for the internal organs to move out of the way of the descent of the diaphragm and to remain there as long as possible during exhalation. The exercise was illustrated with visuals demonstrating the muscular action of the abdominal muscles as they relax during inspiration, actions of the intercostal muscles, rib cage, lungs, and the diaphragm muscle during deep inhalation.

3. Subjects repeated exercise 2 with the exception that, during exhalation, subjects will played an open "G" on the clarinet, the left hand remaining against the left side of the abdomen.

Exercises of Exhalation: Lessons 5 - 10

Exercises to improve controlled expiration included diagrams of respiratory muscle activity, air pressures, lung volumes, and air flow rates during clarinet performance. Physical exercises to improve respiratory muscle control and strength included activities such as the following:

Exercises for Development of Respiratory Muscles

Included were diagrams, illustrations, and models, in addition to exercises. Subjects repeated exercise 2 above, using diagrams to illustrate muscular activity associated with forced expiration; controlled ascent of the diaphragm due to control of the abdominal muscles, elastic recoil of the lungs, and braking action of the inspiratory muscles during the onset of controlled expiration.

Exercises for Development of Controlled Airway Pressures

Three methods were utilized: inflating balloons, observing and manipulating a water manometer, and studying visual illustrations of air pressures during clarinet performance.

1. Subjects inflated balloons, while attending to the pushing sensation in the abdomen area. To supply enough energy to perform on the clarinet, a minimum of 40 centimeters of water pressure must be applied.

2. Sustained pitches were played on the clarinet, attempting to reproduce a similar sensation to that which was experienced when inflating the balloon.

3. After observing the instructor exhale into the tube attached to the water manometer, subjects attempted to sustain an airway pressure of 40 cm H_20, exhale into the tube and attempted to sustain an air pressure of 40 cm H_20 (Bouhuys, 1964). This exercise illustrated the importance of maintaining the airway pressure at all times.

4. After observing the instructor insert the water manometer tube into the mouth while performing low, middle, and high range pitches on the clarinet, all

at mezzo forte dynamics, subjects attempted to produce the same tones at a mezzo forte dynamic range and measured the resultant airway pressures as compared with those of the instructor.

5. Subjects repeated exercise 4 at varying dynamic levels to illustrate changing pressures for changing dynamics. Visual charts depicting airway pressures that have been measured for varying pitches at specific dynamic levels reinforced the pressures necessary for specific pitches and dynamic levels (Bouhuys, 1964).

Exercises for Development of Controlled Lung Volumes

Exercises included examination of lung volume variations during clarinet performance and their relationship to air pressure using two methods; exhaling into a closed tube versus an open tube, and observing visual charts.

1. Subjects compared the length of time that an open "G" could be sustained on the clarinet to the length of time that 40 centimeters of water pressure could be sustained by exhaling into the closed tube attached to the water manometer. The loss of lung volume attributed to the increased air flow caused greater difficulty in maintaining the pressure.

2. A chart was used to demonstrate the relationship of diminishing lung volumes to the proportional increase of work required by the abdominal muscles to maintain the necessary airway pressure throughout a breathing cycle.

Exercises for the Development of Controlled Air flow Rate

Exercises included the examination of the relationship of air flow rate to changes due to dynamics and pitch as well as the examination of charts showing that air flow increases with dynamics and that muscular support must increase as lung volumes decrease. Subjects practiced long tones beginning at pianissimo with crescendo to fortissimo over a period of eight seconds. Secondly, subjects performed a crescendo and a diminuendo for a total of sixteen seconds. As air supplies became low, subjects experienced increased airway pressures to maintain the pitch even though the dynamics become pianissimo. This exercise demonstrated the relationship of increased air pressure to diminishing lung volumes.

Treatment 2: Traditional Method

The traditional method of teaching breath management included exercises to strengthen breath management skills with little or no explanation involved in the actual exercises, foundation being that physiologic explanations would cause confusion among students (Pino, 1990). The traditional method in this study was based sequentially on exercises and information found in seven woodwind instructional texts: The Art of Saxophone Playing, Teal (1963); The Art of Woodwind Playing, Weisberg (1993); The Art of Clarinetistry, Stubbins (1965); The Teaching of Instrumental Music, Goolsby and Colwell (1992); The Clarinet and Clarinet Playing, Pino (1980); The Art of Clarinet Playing, Stein (1958); and Guide to Teaching Woodwinds, Westphal (1990). Included in this paper are representative exercises from these texts which are divided into exercises of inhalation and exhalation.

Inhalation Exercises

The following exercises were found in Goolsby & Colwell (1992):

1. Imagine stepping into a cold shower on a hot day and gasp as you imagine the air rushing deep inside, as if to the stomach.

2. Imagine taking an unmannerly "slurp" of soup. Actually make the sound, then duplicate the sound silently.

3. Sit in a chair and lean forward with the chest touching or almost touching the knees and the arms extending beside the legs to the floor. Breathe

4. Inhale several short breaths in sequence. For instance, before playing a whole note, inhale on the four preceding counts.

5. Stand with the heels and shoulder blades touching the wall. Inhale without moving the shoulders or chest.

6. Inhale as though yawning.

7. Inhale as in a relaxed gasp.

8. Sniff a rose.

Exhalation Exercises

The following exhalation exercises are from Goolsby & Colwell (1992):

1. Pretend to blow out the candles on the birthday cake at your one hundredth birthday.

2. Inhale while the teacher counts aloud to four, then exhale while hissing for twelve counts.

3. Pretend to blow the air through the horn, through the stand, and through the wall.

4. Hiss in imitation of a teakettle.

Representative exercises from Pino (1990) that were incorporated included:

1. Compare the airstream with the bow of a violin. The distance that the bow travels across the string to make a strong sound is comparable to the clarinetist allowing the air to travel a long distance to produce a rich tone.

2. Low, soft notes on the clarinet will be compared to large, heavy trucks smoothing out tar on a road; slow and powerful. High, loud tones will be compared to a huge truck speeding down the highway; powerful and fast.

3. Attempt to put pressure upon an imaginary balloon inflated inside the waistline in such a way as to hole the air ready for sending it out at the proper time.

Treatment 3, Control Group

The control group received instruction in rhythmic reading, correct hand position, finger positions for new pitches, steady beat, and specific exercises in Best of Class, Book 1.

Representative Lesson Plan for PBM

Exercises of Introduction, Lesson 1

1. I'd like to hear everybody play an open "G" on your clarinet. Can you play that louder? Can anybody tell me what you did differently to play louder? You took a bigger breath, anything else? You blew harder? Anything else?

How about the first "G" you played - how did you play that? Did you take a breath like you do when you're, say, watching TV? No? What was different about the way you breathed to play that "G"? Do you breathe like this to watch TV (demonstrate breathing through the corners of the mouth)?

So, when we breathe to play a clarinet we do something special in the way we breathe in and the way we breathe out. Do you think that if we figure out the best way to breathe in and out to play the clarinet that we'll be better clarinet players? How do you think we'll be better? Maybe play louder, how about softer? How about how pretty we sound, our tone. Do you think that will get better? Anything else?

2. First, let's sit up straight so that our body will work better. We want our ribs to have room to expand and everything needs to work properly without other parts of our body getting in the way. So, sit with both of your feet on the floor. Your bottom will have to sit away from the back of the chair so that your feet can be flat on the floor. Let me see you do that. Good.

3. This slinky is like the ribs in this picture. If you are hunched over like this, your ribs cannot expand. But, if you are sitting up straight like this, your ribs will move apart and your lungs will be able to fill up with air. Hold your hands up over your head, hands touching above your head. Now lower them until they are straight across your shoulders. Pretend that there is a string attached to your chest bone on one end and the ceiling on the other end. Lower your arms but continue to feel the sensation of the string attached to your chest.

4. Now, let's play that "G" on the clarinet again, but first remember to put both feet on the floor, feel the string, relax your shoulders, take a deep breath out of the corners of your mouth, now blow.

5. Breathe in two, three, four; blow, two, three, four. Breathe in two, three, four; blow, two, three, four.

6. Let's play the exercise that you are working on in class. What are we going to remember while we play? Breathe in , two, three, four . . .

7. Critique exercise with notes on keeping embouchure firm, hands relaxed, etc.

8. Remember, you must practice for ten minutes each night. Be sure that you are sitting correctly, and when you do your exercises from the book, check your posture, and breathe in and out the way we practiced.