THE EFFECTS OF BIOFEEDBACK AND VERBAL FEEDBACK ON THE TRAINING AND MAINTENANCE OF DIAPHRAGMATIC BREATHING

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The purpose of this study was to evaluate the effects of a computer program on the training and maintenance of diaphragmatic breathing. The biofeedback portion was visual computer training and the results were displayed concurrently with participants' breathing responses to monitor display. The verbal feedback portion was praise that was given and recorded when participants responded with predominantly diaphragmatic breathing at the scheduled moment and response instruction that was given when participants responded with predominantly thoracic breathing. The results of this study indicate the computer program's effectiveness needs to be increased by supplementation with verbal feedback.

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CHAPTER 1

INTRODUCTION

People engaging in biofeedback therapy are often so tense at the beginning of the session that they might not become relaxed until the session is finished completely, which hinders full benefit from the therapeutic experience (Schwartz & Schwartz, 1995). One of the major components of relaxation is diaphragmatic (abdominal) breathing. During diaphragmatic breathing the double dome shape of the diaphragm extends up under the lungs when at rest. Upon inhalation, the diaphragm descends after contracting and flattening downward allowing the lungs to fill and the belly to expand. Upon exhalation, the diaphragm returns to its normal resting state. This exhalation is generally full and deep, involving the respiratory muscles of the chest and the belly, lower ribcage, and lower back. Gradually, breathing slows down and each breath takes in more oxygen and releases more carbon dioxide. This slower breathing, combined with the rhythmical pumping influence of the diaphragm, abdomen, and belly, helps engage a parasympathetic nervous system element called the relaxation response (Benson, 1975; Schwartz, 1995).

Diaphragmatic breathing is deemed so important for clinical practice that it is suggested to be used in conjunction with other procedures when treating, for example, hyperventilation, chest pain, and panic (Schwartz, 1995; Stout and Creer, 1993). However, empirical evaluations of the effects of diaphragmatic breathing are scarce. In addressing hyperventilation syndrome (HVS), Schwartz (1995) expressed surprise at the paucity of studies showing the effects of breathing therapy alone for HVS. He also commented on the lack of studies on chest pain showing a combination of behavioral, psychopharmacological, and breathing therapies as well as the lack of comparisons among these therapeutic approaches; also, on the lack of controls and specificity of breathing therapy on the treatment of panic. Similarly, Garssen, de Ruiter, and van Dyck (1992) remarked that breathing retraining could be a rational placebo (logical and makes sense but of no remedial value) even though together with other procedures it is therapeutically effective. Ley (1992) replied in defense that breathing retraining needs a more evenhanded evaluation. Lehrer and Woolfolk (1994) suggested that, while breathing retraining has not been proven a critical element of relaxation techniques, it probably is. Nonetheless, some studies point to the importance of including diaphragmatic breathing as a component of training relaxation. MacHose and Pepper (1991) assumed in their group study of 17 that diaphragmatic breathing is an important part of relaxation training protocols. They also revealed that inhalation volume increased about 30% after loosening the clothing of the participants. Both training relaxation and loosening clothing are basic elements of biofeedback therapy.

Because many people predominately breathe with their chest (thoracic breathing), and because tension and arousal frequently accompanies thoracic breathing, clinicians and biofeedback therapists often have to train diaphragmatic breathing to help facilitate some degree of relaxation. There are several techniques to promote diaphragmatic breathing. However, there are few studies of training and maintaining diaphragmatic breathing showing the results and how they were achieved. Some techniques that do not include biofeedback or physiological monitoring are slow diaphragmatic breathing, paced respiration, pursed-lip breathing, and rebreathing (Schwartz, 1995). Slow diaphragmatic breathing generally aims for a respiration goal of 6 to 8 breaths per minute (bpm) and can be can be trained with a light sandbag or a telephone directory placed on the abdomen (Schwartz, 1995). Clark and Hirschman (1990) suggest the use of paced respiration in therapeutic situations such as panic attacks. The use of an external pacing signal such as alternating tones or a metronome is suggested. Incidentally, their subjects' average rate of 11 bpm was reported, but their tables showed 13 to 14 bpm averages, so (Schwartz, 1995) states their results may be questionable. Rebreathing is a procedure that involves having the patient take 6-12 natural breaths in a paper bag covering the mouth and nose, and results in abdominal breathing (Holloway, 1994). This is not considered a relaxation technique. Pursed-lip breathing, partially closing the mouth to exhale after taking a small, inhaled breath, is used mostly for people with chronic obstructive pulmonary disease (Berkow & Fletcher, 1992).

Biofeedback is the technique of using monitoring devices to measure and "feed back" autonomic activity; (e.g., heart rate or temperature), affording the opportunity to gain some voluntary control over those functions (Olson, 1955). Biofeedback techniques used to enhance relaxed breathing include the use of nasal-air-flow temperatures, electromyography from accessory breathing muscles, inspirometer, noncontact respiration feedback, and strain gauges (Timmons and Ley, 1994; Schwartz, 1995). These are all essentially noninvasive, in the sense that no instruments are inserted into the body. The biofeedback equipment can measure many physiological responses (e.g., heart rate, temperature, muscle tension, skin moisture response) and can be programmed to give an auditory or visual signal at specific values of measured responses. Runck (1983) likens this feedback to household devices such as a mirror, scales, or thermometer. Appropriate instrumentation can measure physiology and stimuli can be "fed back" by the auditory/visual signal to give an individual the opportunity to regulate these sensory stimuli by responding to the feedback stimuli. For example, these auditory signals may be continuous and go higher and lower, or they may be discrete and turn on and off depending upon the protocols and the preferences of the participant. As an example, if one were trying to increase his/her temperature it would seem to call for the continuous and higher tone since the goal is to achieve and maintain a high temperature. If one were trying to decrease his/her muscle tension it would seem to call for a discrete on/off, so when the tension got low enough the tone might be set to go silent. The breathing equipment used in this study depended upon visual feedback only. According to Schwartz (1995), there is no research showing any differential outcomes among alternative biofeedback procedures to train diaphragmatic breathing, and some reports suggest that biofeedback programs need to be supplemented with verbal feedback and instructions.

This study was conducted to evaluate the effects of computer-programmed feedback on training diaphragmatic breathing and its maintenance in the absence of the computer feedback. A second purpose of the study was to evaluate the effects of response instructions and praise on the diaphragmatic breathing generated by the biofeedback training and baseline conditions.

CHAPTER 2

METHOD

Participants

Three participants were recruited through an advertisement in the campus newspaper at the University of North Texas in Denton, Texas. Two females (JR and NV) ages 20 and 67, respectively, and one male (RC) age 47, were selected because they showed a predominant pattern of thoracic breathing. They were paid $5.00 immediately after each session ended.

Setting and Apparatus

Focus Technology F1000 with Heart Rate/Respiration Option using a VGA monitor was used to record and monitor physiological responses. Data collected included temperature, electrodermal response (EDR), heart rate, and respiration pattern. Equipment was located in one of the counseling rooms at the Biofeedback Research and Training Laboratory at the University. The same room and equipment was used for all sessions for all participants. The room was small, private, quiet, and comfortable. The room contained computer/biofeedback equipment, a small table for hook-up supplies, two chairs, and a reclining chair that the participants used in the semi-reclining position during the session.

Measurements

In biofeedback therapy, some physiological readings are normally accepted as indicators that relaxation is occurring (e.g., when temperature readings are high, EDR and heart rate is low, and abdominal breathing is occurring). Temperature, EDR, and heart rate readings were taken to indicate that conditions were favorable for the participants to engage in the desired outcome of abdominal breathing and to make sure they were feeling no physical distress or discomfort. These readings were monitored during sessions but were not part of the study's focus. The response of primary interest was the respiration pattern. In order to take these measurements, participants reclined in a chair and clothing and equipment were adjusted to assure comfort and proper body contact with equipment sensors. One elastic respiration strap with transducer was placed around the subjects' chest and another strap with a transducer around the stomach. Rather than measuring respiration, it is a measurement of force since the elastic straps are translating body circumference into force against the respiration transducers. The breathing patterns were automatically graphed during the session from responses measured by the transducers. This provided a comparative measurement of abdominal and chest breathing activity. During the sessions, the computer screen displayed the breathing activity in motion with horizontal red (thoracic) and green (diaphragmatic) bars. After the sessions, the computer displayed a graph showing the breathing activity amplitudes with red (thoracic) and green (diaphragmatic) lines.

Procedures

Phase I

Pretest. At the beginning of the session, the participants were prepared by adjusting their clothing, chair position, and equipment sensors as described in the measurement section. He/she was then instructed to close his/her eyes and relax. The computer screen was turned off and silence maintained for 10 minutes.

Phase II

Biofeedback training. Experimental sessions lasted for about 23 min and consisted of 1) approximately 3-min preparation, 2) 5-min baseline, 3) 10-min computer visual feedback training, and 4) 5-min baseline. During the first and second 5-min baselines, the participant was instructed to close his/her eyes and relax. The computer screen was turned off and silence maintained. During the 10-min visual feedback training the Paced Respiration Ball screen was displayed. The moving ball bounces off each side of the window at the selected rate of 8 bpm. The vertical position of the ball, which can be controlled by diaphragmatic breathing only, reflects the respiration measured. As the participants inhale or exhale the ball will rise or fall. The template curve displayed in the window guides the participant's respiration rate. The curve also guides the length of the pause between breaths. During this training the participants were instructed to "open your eyes and breathe the ball along the curve using your stomach, not your chest." At the middle of biofeedback training (minute 10) a response instruction “breathe with your stomach, not your chest” was delivered.

Phase III

Verbal feedback. During the 10-min biofeedback training either praise or response instructions were delivered every two minutes depending upon the breathing response occurring as indicated by the horizontal bars at the bottom of the screen. Praise, "GOOD, you're breathing with your stomach!," was delivered only if the participant was breathing predominantly with their stomach at that scheduled intervention time. The response instruction "breathe with your stomach, not your chest" was delivered if at that scheduled moment the participant was breathing predominantly with their chest. To replicate the effects of praise and response instructions, they were also implemented during some baselines after they were instructed to "close your eyes and relax."

Phase IV

Posttest. Just as in Phase I Pretest, each participant was first prepared and then instructed to close his/her eyes and relax. The computer screen was turned off and silence maintained for 10 minutes.

Experimental Design.

Two designs were used. A reversal design was used to test the biofeedback procedure: 5-min baseline, 10-min training, 5-min baseline. A multiple baseline design across subjects was used to test the effects of verbal feedback: RC began with praise after 1 session of Biofeedback Training, NV after 4 sessions of Biofeedback Training, and JR after 6 sessions of Biofeedback Training.

CHAPTER 3

RESULTS

The line graphs show the thoracic (red line) and the diaphragmatic (green line) breathing patterns and heart rate (blue line). Heart rate, although monitored, is part of the graphed results because line could not be removed from the computer printout. The scale on the left vertical axis is for the heart rate. The scale on the right vertical axis is used to indicate the size of the graph. On a smaller scale e.g., maximum 20 instead of 30, the peak of high amplitudes would not be shown on the graph. Thus, the scale does not measure thoracic or diaphragmatic breathing, but allows a choice of the size of the display on the graphs. So all of the line graphs were shown on the size 30 scale so they would be displayed on the same scale. To quantify respiration patterns, a ruler was used to measure in millimeters the amplitudes of the breathing patterns each minute of the session duration. The smooth (not jagged) lengths of the amplitude obtained were then expressed as a percentage of the total breathing activity. For example, if during the 5-min baseline the 5 green 1-min amplitude lengths measured a total of 14mms and the 5 red 1-min amplitude lengths totaled 6mms, then dividing the total sum of 20mms into the 14mm green portion would show 70% diaphragmatic breathing during that baseline. The author devised this measurement system since the computer did not provide any absolute quantities. The graphed amplitude size varied from session to session on each participant because of the tightness of the straps, the sensitivity setting, posture, clothing, and other artifacts. However, the percentage of the diaphragmatic breathing for each session for each participant is a quantity that can be used to compare the breathing of each participant across sessions and across participants. The percentage does not depend upon the amplitude size of other sessions, but only upon relative amplitude sizes during each separate session. These percentages can then be used to compare relative increases (or decreases) between the sessions. While this quantifying approach is unique to the software program used in this study, Peek (1995) stated that skin conductance response (SCR) arousal measurements are better gauged as percentage of change from baselines rather than as absolute change. He said this was like expressing a year's growth in the national product as a percentage increase over the previous year's level rather than as an increase of so many dollars. Although he was talking about autonomic arousal, the rationale applies to diaphragmatic and thoracic breathing.

The graphs shown are representative of the effects obtained during all experimental conditions (approximately 12-19 sessions per participant.) These graphs show the pretest, the posttest, the last biofeedback training, the first response instruction intervention, the first praise intervention, and the first baseline intervention.

Figure 1 shows the pretest and posttest measures of the diaphragmatic and thoracic breathing for RC. The top graph shows a 10-min baseline pretest, the middle graph shows a 10-min baseline posttest, and the bottom graph shows the percentage of breathing during pretest and posttest. During pretest (top graph), thoracic breathing was higher throughout the 10-min test. During posttest (middle graph), diaphragmatic breathing was predominant. Overall (bottom graph), diaphragmatic breathing was 47% of the total breathing during pretest and 80% during posttest, which represents an increase of 70% over the pretest.

Figure 2 shows the diaphragmatic and thoracic measures for RC during the baselines and training conditions of the last session of the biofeedback training with response instruction at the 10-min interval (Session 1). The top graph indicates baseline 1, biofeedback training, and baseline 2 to show evenly divided diaphragmatic and thoracic breathing. The only difference between baselines and training was an increased breathing activity during biofeedback training. The bottom graph shows diaphragmatic breathing to be 50% during baselines 1 and 2, and 49% during training.

Figure 3 shows the diaphragmatic and thoracic measures for RC during baselines and training conditions of the first verbal feedback (praise) training phase (Session 2). During baseline 1, his diaphragmatic breathing was predominant as well as during training. During baseline 2, the breathing returned to baseline 1 level. The bottom graph shows the percentages of diaphragmatic breathing during the 5-min baselines 1 and 2; they were 61% and 64%, respectively. The 10-min training phase resulted in an 87% predominance of diaphragmatic breathing.

Figure 4 shows the diaphragmatic and thoracic measures for RC during baselines, biofeedback training, and the first verbal feedback (response instructions) during baseline 2 (Session 8). During baseline 1, his diaphragmatic breathing was even except for the spike on the fifth minute. During biofeedback training, the diaphragmatic breathing was predominant, and during baseline 2 with intervention the breathing was variable but close to baseline 1 level. The bottom graph shows the diaphragmatic breathing during the 5-min baselines 1 and 2 with intervention, the percentages were 74% and 70% respectively. An average breath of the previous 4 minutes would have resulted in about a 50%

Baseline 1 instead of 74%. The 10-min training portion resulted in an 84% predominance of diaphragmatic breathing.

Figure 5 shows the diaphragmatic and thoracic measures for RC during baselines, biofeedback training, and the first verbal feedback (praise) during baseline 2 (Session 10). During baseline 1, his diaphragmatic breathing was higher. During biofeedback training, the diaphragmatic breathing was predominant. During baseline 2 with interventions, his diaphragmatic continued to be predominant. The bottom graph shows the percentage of diaphragmatic breathing during the 5-min baselines 1 and 2 are both 57%. The 10-min training portion resulted in a 60% predominance of diaphragmatic breathing.

Figure 6 shows the pretest and posttest measures of the diaphragmatic and thoracic breathing for NV. The top graph shows a 10-min baseline pretest, the middle graph shows a 10-min baseline posttest, and the bottom graph shows the percentage of diaphragmatic breathing during pretest and posttest. During pretest (top graph), diaphragmatic and thoracic breathing was about even throughout the 10-min test. During posttest (middle graph), her diaphragmatic breathing was predominant. Overall (bottom graph), her diaphragmatic breathing was 49% of the total breathing during pretest and 76% during posttest which represents an increase of 55% over the pretest.

Figure 7 shows the diaphragmatic and thoracic measures for NV during the baselines and training conditions of the last session of the biofeedback training with response instruction at the 10-min interval (Session 4). During baseline 1, thoracic breathing was higher. During biofeedback training and baseline 2, diaphragmatic breathing was predominant. Although the line graph is the same size, the heart rate failed to record and there was no left vertical scale. The bottom graph shows that the percentage of diaphragmatic breathing was 43% and 67% in Baseline 1 and 2, respectively, and 54% during the 10-min Training.

Figure 8 shows the diaphragmatic and thoracic measures for NV during the baselines and training conditions of the first session of verbal feedback (praise) training phase (Session 5). During baseline 1, thoracic breathing was greater. During training, the diaphragmatic breathing was predominant, and during baseline 2, the breathing returned to baseline 1 level. The bottom graph shows the percentage of diaphragmatic breathing during the 5-min baselines 1 and 2 are 47% and 48%, respectively. The 10-min training portion resulted in a 69% predominance of diaphragmatic breathing.

Figure 9 shows the diaphragmatic and thoracic measures for NV during the baselines, biofeedback training, and the first verbal feedback (response instruction) during baseline 2 (Session 8). During baseline 1, thoracic breathing was highest. During biofeedback training, the diaphragmatic breathing was predominant. During baseline 2 with intervention, the diaphragmatic breathing was predominant. The bottom graph shows that the percentage of diaphragmatic breathing during the 5-min baseline 1 was 42% and 73% during baseline 2 with intervention. The 10-min training portion resulted in a 75% predominance of diaphragmatic breathing.

Figure 10 shows the diaphragmatic and thoracic measures for NV during baselines, biofeedback training, and the first verbal feedback (response instruction) during baseline 1 (Session 10). During baseline 1 with intervention, diaphragmatic breathing was predominant. During biofeedback training, the diaphragmatic breathing was also greater, and during baseline 2 with intervention, the breathing continued to be predominant. The bottom graph shows that the percentage of diaphragmatic breathing during the 5-min baseline 1 was 74% while baseline 2 was 82%. The 10-min training portion resulted in an 82% predominance of diaphragmatic breathing.

Figure 11 shows the pretest and posttest measures of the diaphragmatic and thoracic breathing for JR. The top graph shows a 10-min baseline pretest, the middle graph shows a 10-min baseline posttest, and the bottom graph shows the percentage of diaphragmatic breathing during pretest and posttest. During the pretest (top graph), thoracic breathing was predominant. During posttest (middle graph), thoracic and diaphragmatic breathing was close to being even. Overall (bottom graph), diaphragmatic breathing was 24% of the total breathing during pretest and 43% during posttest which represents an increase of 79% over the pretest.

Figure 12 shows the diaphragmatic and thoracic measures for JR during the baselines and training conditions of the last session of the biofeedback training with response instruction at the 10-minute interval (Session 6). The top graph shows that during baseline 1, neither diaphragmatic nor thoracic breathing is predominant. During biofeedback training, the breathing activity increased but the proportions of diaphragmatic and thoracic breathing remained close to baseline levels. Baseline 2 shows thoracic breathing predominant. In the bottom graph, baseline 1 diaphragmatic breathing was 51% and baseline 2 was 23%. The biofeedback training percentage of 50% diaphragmatic breathing is skewed because of the spike at the l5-min interval. If that breathing had been the average breathing over the previous 9 min, it would have resulted in about 60% instead of 50% of diaphragmatic breathing.

Figure 13 shows diaphragmatic and thoracic measures for JR during the baselines and training conditions of the first session of verbal feedback (praise) training phase (Session 7). During baseline 1, diaphragmatic breathing was slightly greater. During training, the diaphragmatic breathing was predominant. During baseline 2, the breathing returned to baseline 1 levels. The bottom graph shows the percentage of diaphragmatic breathing. The 5-min baselines 1 and 2 were both 64%, though neither diaphragmatic nor thoracic breathing shows much activity as can be seen in the top graph. Shallow breathing creates the possibility of high percentages for a small visual amount of differences. The 10-min training portion resulted in a 78% predominance of diaphragmatic breathing.

Figure 14 shows diaphragmatic and thoracic measures for JR during the baselines, biofeedback training, and the first verbal feedback (response instructions) during baseline 2 (Session 14). During baseline 1, diaphragmatic breathing was higher and also predominant during biofeedback training. During baseline 2, diaphragmatic breathing was still greater than the thoracic. The bottom graph shows the percentage of diaphragmatic breathing during baseline 1 was 64% and baseline 2 with intervention was 59%. Neither shows much activity as can be seen in the top graph. The 10-min training phase resulted in a 66% predominance of diaphragmatic breathing.

Figure 15 shows diaphragmatic and thoracic measures for JR during baselines, biofeedback training, and the first verbal feedback (praise) during baseline 2 (Session 16). During baseline 1, thoracic breathing was higher. During biofeedback training, the diaphragmatic breathing was predominant, and during baseline 2 it was greater than baseline 1. As can be seen in the top graph, the level of abdominal breathing in both baseline 1 and baseline 2 was nearly the same, but thoracic breathing was greater in baseline 1 than in baseline 2, thereby reducing predominance of the diaphragmatic portion in baseline 1. The 10-min training phase resulted in a 64% predominance of diaphragmatic breathing. The bottom graph shows the percentage of diaphragmatic breathing during baseline 1 was 41% and 72% during baseline 2.

CHAPTER 4

DISCUSSION

The results of this study show that the computer software used alone to train diaphragmatic breathing had mixed results during training, and these results did not maintain during subsequent baselines. Better overall results were seen when differential response instructions and verbal feedback (praise) were added to the biofeedback training and baseline conditions. During training RC improved diaphragmatic breathing from 49% to 87% and during baseline from 64% to 70%. During training NV improved diaphragmatic breathing from 54% to 69% and during baseline from 48% to 73%. During training JR improved diaphragmatic breathing from 50% to 78% but during baseline declined from 64% to 59%.

These results support the notion that biofeedback procedures are more effective if they are supplemented with patient education, instructions, and verbal guidance (Olsen, 1995; Schwartz & Schwartz, 1995). However, there are few clear, concise instructions on what to say to clients and when to say it. A procedure containing precise instructions was clients using the incentive inspirometer, which is a device that has a calibrated cylinder and measures breath inhalation and teaches slow breathing. For example, Peper and Tibbets (1994) listed 31 instructions (from loosening clothing to postinstructions) used during introduction, baseline recording, and diaphragmatic breathing procedures. However, these descriptions and instructions were delivered without any systematic relation to the performance of the client. Among the 31 items, 8 corresponded to diaphragmatic breathing and consisted of the general statements explaining diaphragmatic breathing and its rationale to the client (Schwartz, 1995). In contrast, this study's response instructions and verbal feedback were effective because they were used explicitly to shape the breathing patterns by praising abdominal movements and instructing to breathe with the stomach when the participant was breathing with the chest. Every two minutes the schedule called for response instruction or verbal feedback (praise), the criteria was whether or not diaphragmatic breathing was occurring at those moments. If so, verbal feedback was given. This had the effect of increasing the diaphragmatic breathing activity by selectively reinforcing diaphragmatic breathing. Skinner (1938) called this selective reinforcement the "differentiation of response" when he was describing the force of bar pressing, (see Keller & Schoenfeld, l950). Sometimes this verbal feedback procedure increased the total breathing activity resulting in the diaphragmatic portion being predominant but the thoracic breathing being proportionally greater than in preceding sessions. Sometimes the contingencies were resulting in greater diaphragmatic breathing but perhaps a smaller percentage of proportion.

There could be many reasons why the computer feedback did not adequately maintain training behavior gains. During the 10-minute training period, the participants were required to not only breathe diaphragmatically to move the ball, but they needed to visually track the ball's progress when breathing the ball along the curve. This visual stimulus control was absent during the baselines and this change appeared to be enough to disrupt performance. These results suggest that, in order to program maintenance, the visual feedback needs to be faded out. Alternately, this study suggests that instructions and praise can be used to program the maintenance of diaphragmatic breathing during baseline conditions. When intervening with response instructions and/or praise diaphragmatic breathing following the verbal feedback increased considerably and sometimes the thoracic breathing percentage increased. In NV – Figure 15, Baseline 1, when response instructions were applied, the result was a substantial increase in diaphragmatic breathing. The response instructions and verbal feedback had been paired with the computer visual and breathing stimulus control during training, so it is highly probable that generalization may be facilitated during baseline interventions, as well as during the posttests, by bringing a common element from training to baseline (cf. Program Common Stimuli, Stokes & Baer, 1977).

Another important maintenance problem is that diaphragmatic breathing does not seem to be a behavior that has positive consequences in the natural environment. The basic concept that behaviors need to be followed by reinforcement to maintain (Cooper, Heron, & Heward, 1987) brings up the problem of natural environment reinforcement. Skinner (1974) gave examples of autonomic behavior being made more conspicuous; (e.g., a certain heart rate turns on a light and reinforcement follows), but he stresses the behavior is not being reinforced by the natural environment. In this study, generalization over time, settings, and places was not deliberately trained and, from the data in posttraining and the next session's pretraining baselines, generalization, in the sense of maintenance, was not occurring. Significantly, this is seen during the participants' performance during Baseline 1. Other generalization techniques need to be used in order to program generalization in the natural environment (Kirby and Bickel, 1988.) Perhaps Stokes & Bear (1977) Introducing the Behavior to Natural Maintaining Contingencies to program generalization can be used to this end. They say their idea of generalization is pragmatic in that if the trained behavior occurs across settings, behaviors, subjects, and time that are different from training and scheduled events during training, the behavior has generalized. However, measurement in the natural environment can be cumbersome; perhaps the measures obtained during Baseline 1 in each session could possibly indicate generalization if they reveal large increases in diaphragmatic breathing.

Another reason the software used to train diaphragmatic breathing did not work well by itself could have been the setting of 8 bpm that was used throughout the study as suggested by the tutorial that came with the software. In biofeedback therapy, a therapist would adjust this setting during the session if it appeared the participant would breathe more comfortably at a higher/lower setting. Since all three participants seemed reasonably comfortable and made no complaint, the suggested setting allowed for a more consistent, controlled study. However, it appears on the graph printouts that the breathing was not as smooth and even as it is in many cases, indicating there might have been a "training strain" such as might result when teaching a participant to breathe at a different level. This study was teaching a component of relaxation, not new and different breathing levels that might have been preferred by one of the participants.

Quantifying the graphs was a unique aspect of this study. For practical use in biofeedback therapy, the visual comparison of the red and green lines on the graph was sufficient to judge whether diaphragmatic or thoracic breathing is predominant, and that was the consideration when the software was designed. An analysis benefits from interpreting the comparative results as percentages. There are limitations, however. During the baselines the breathing activity at times was so low that the use of the percentage quantification was stretched; e.g., if the thoracic breath measured 1mm (which was the minimum measurement) and the diaphragmatic measured 2mm then the diaphragmatic breath was a predominate 67% for that minute. On the line graph, this would hardly be noticeable, but on the bar graph, it would appear to be very predominant. The interventions during the baselines had the side effect of alleviating this problem because the increase in breathing activity avoided the minimum-type measurements.

Another limitation was a lack of time for a follow-up second posttest to see if the diaphragmatic breathing level was being maintained. This should have been a planned phase of the study.

If someone were to do a similar study, a suggestion might be made to compare 2 or 3 participants using this study's computerized method with 2 or 3 participants using the book on the abdomen training and the computer for Baseline 1 and Baseline 2 as the comparison criteria.

This study suggests that if the equipment and software is available and the therapist or experimenter has the time, this software contributes to teaching relaxation by increasing diaphragmatic breathing. For it to be more effective there needs to be supplementation with something like accompanying response instructions and verbal feedback contingent on the participant's performance. This study also suggests that verbal feedback contingent on the participant’s performance might be enough to train diaphragmatic breathing.

APPENDIX A

INFORMED CONSENT FORM

STATEMENT OF INFORMED CONSENT

I, _____________________________, agree to participate in a study that evaluates the effectiveness of some normally prescribed biofeedback procedures.

Noninvasive measurements include electrodermal response (EDR) sensors on left palm, breathing gauges placed around chest and stomach, heart rate sensors attached to inside of each wrist and ground on the backside of left wrist, and temperature probe taped to left little finger. The protocol takes 20 minutes plus hookup time and will be conducted at the Biofeedback Lab, Department of Counseling, Development and Higher Education, College of Education, located in Stovall Hall, UNT.

I have been informed that any information obtained in this study will be recorded by code that will allow Mr. Armstrong to determine my identity. Normal procedures of confidentially will be followed. Under this condition, I agree that any information obtained from this research may be used in any way thought best for publication or education.

I understand that there is no personal risk or discomfort directly involved with this research and that I am free to withdraw my consent and discontinue participation in this study at any time.

It has been explained to me that I will receive $5.00 per session. Daily sessions at the time agreed upon will be Monday through Friday during Summer 1 and I will be paid at the end of each session.

If I have any questions or problems that arise in connection with my participation in this study, I should contact Mr. Earl Armstrong, Principal Investigator, at 484-2143.

(Date) ______________________ (Signature of participant) _______________________

(Date) ______________________ (Investigator) __________________________

UNIVERSITY OF NORTH TEXAS COMMITTEE HAS REVIEWED THIS PROJECT FOR THE PROTECTION OF HUMAN SUBJECTS (Phone: 565-3940)

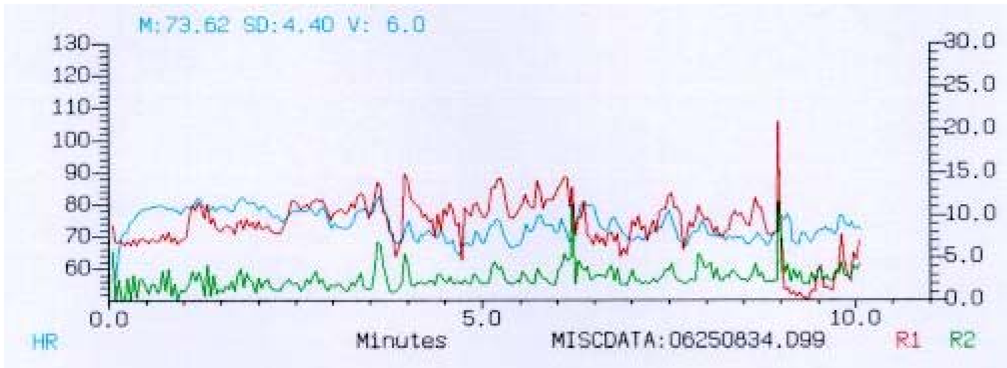
APPENDIX B

FIGURES 1-15

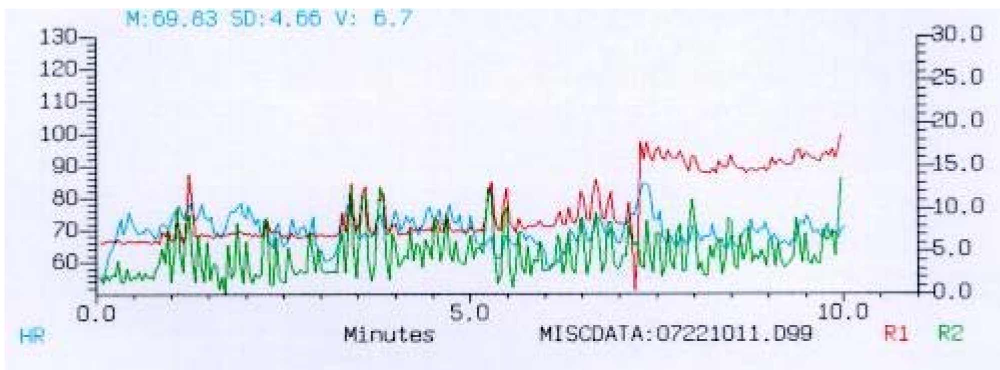
Figure 1. RC – Pretest/Posttest

RC - Pretest

Red = Thoracic
Green = Diaphragmatic



RC - Posttest



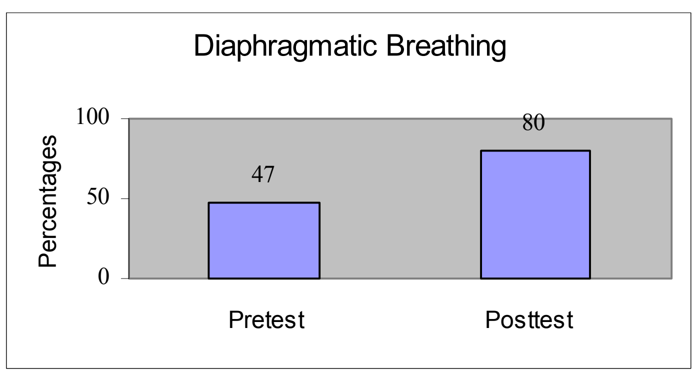


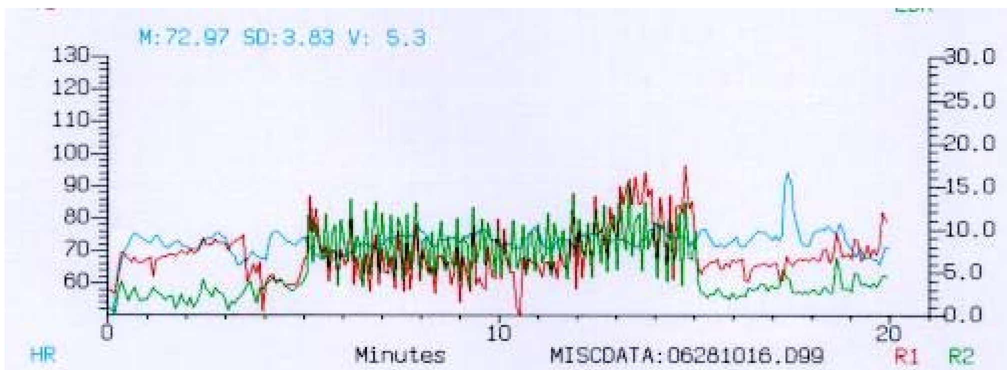
Figure 2. RC – Session 1

RC - Session 1

↓ = General Instructions
∗ = Praise
+ = Response Instructions

Red = Thoracic
Green = Diaphragmatic

↓ + ↓



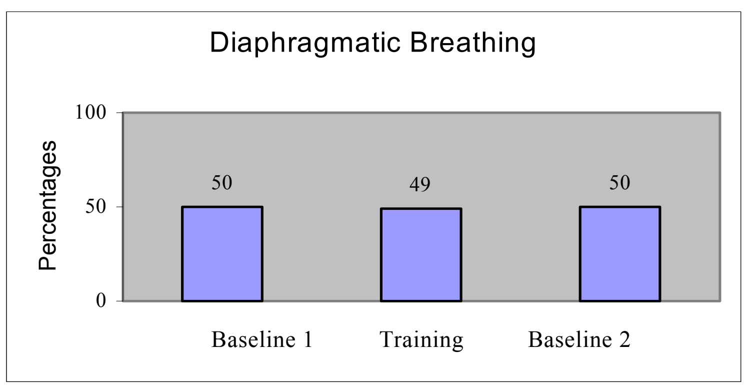


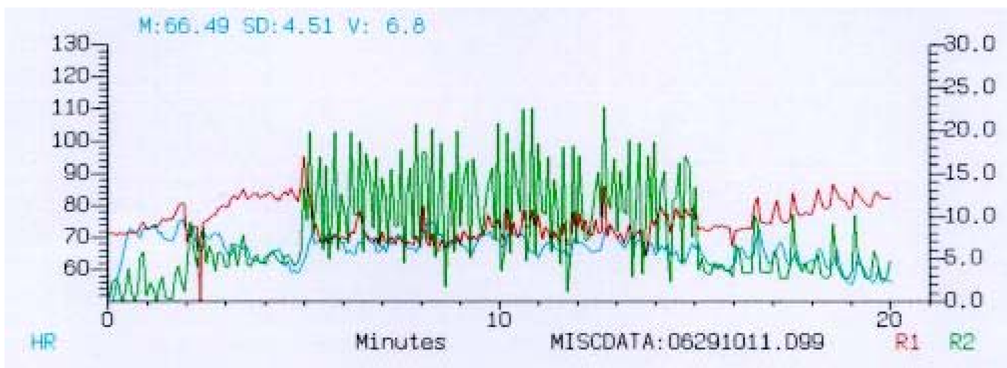
Figure 3. RC – Session 2

RC - Session 2

↓ = General Instructions
∗ = Praise
+ = Response Instructions

Red = Thoracic
Green = Diaphragmatic

↓ ∗ ∗ + ∗ ↓



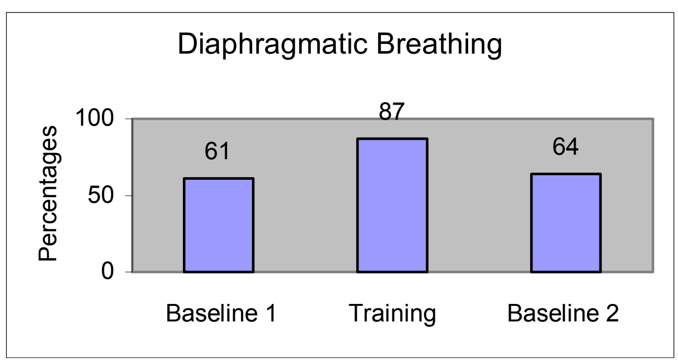


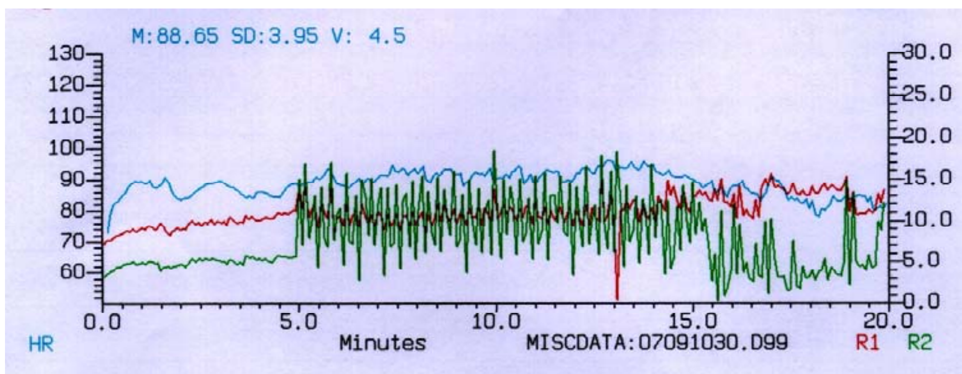
Figure 4. RC – Session 8

RC - Session 8

↓ = General Instructions
∗ = Praise
+ = Response Instructions
# = Interventions

Red = Thoracic
Green = Diaphragmatic

↓ ↓+



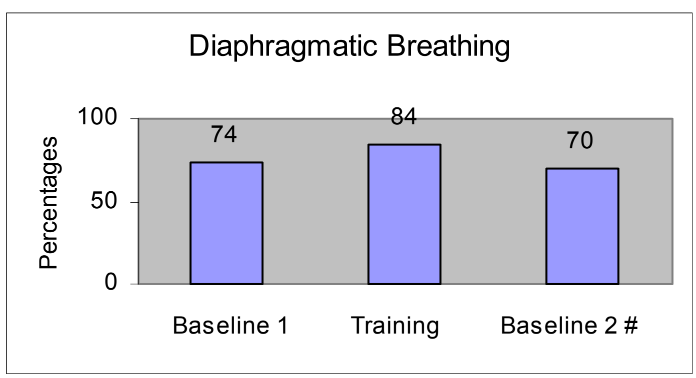


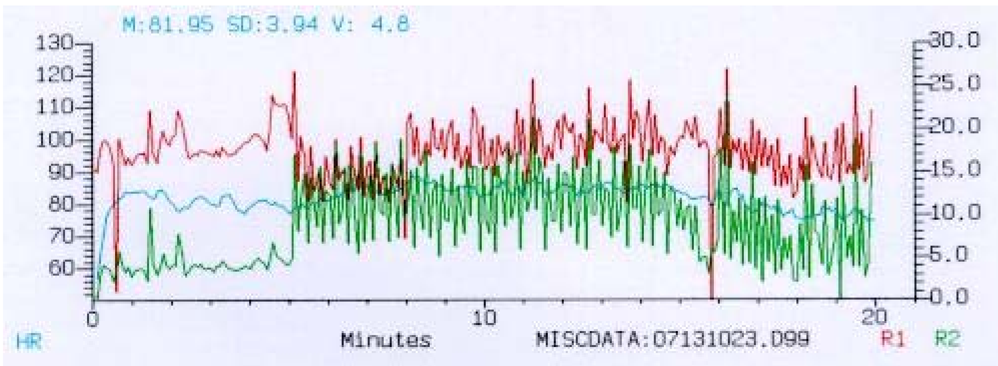
Figure 5. RC – Session 10

RC - Session 10

↓ = General Instructions
∗ = Praise
+ = Response Instructions
# = Interventions

Red = Thoracic
Green = Diaphragmatic

↓ ↓+ + ∗ + ∗



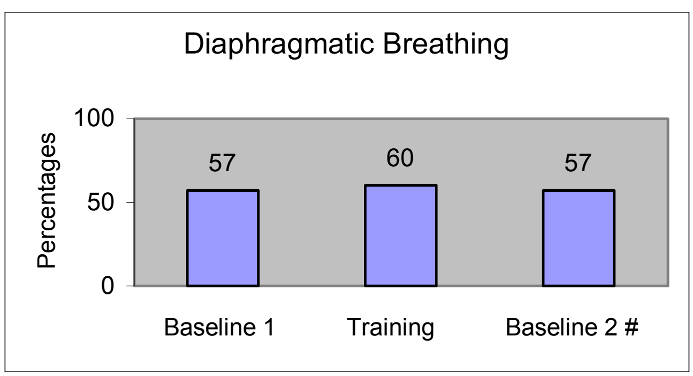
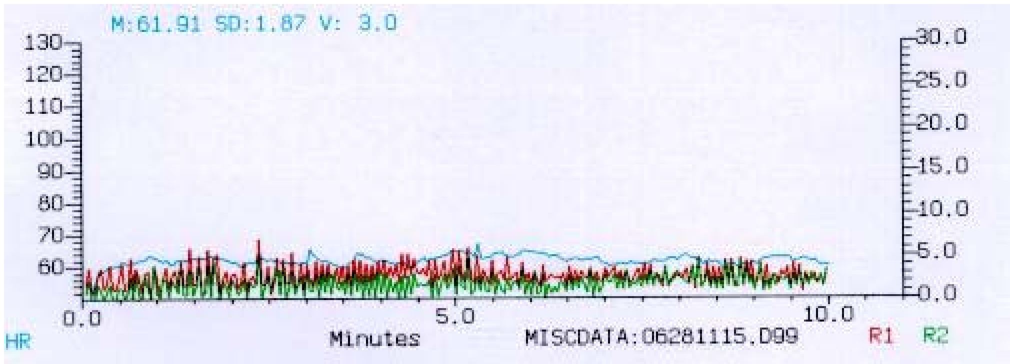


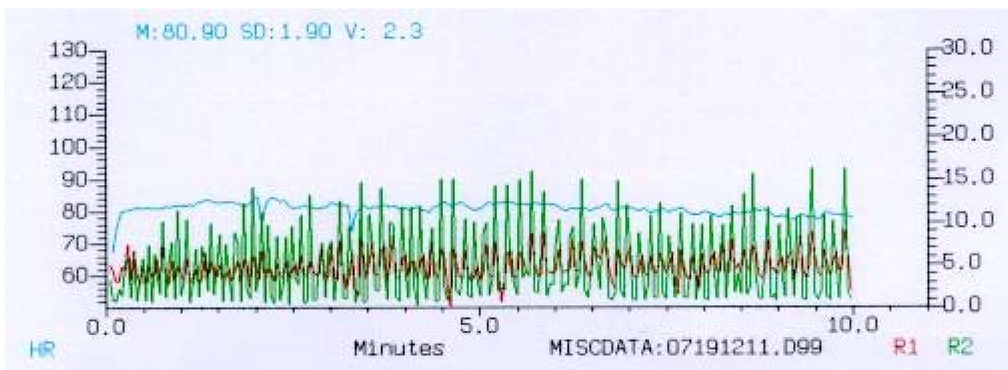
Figure 6. NV – Pretest/Posttest

NV - Pretest

Red = Thoracic
Green = Diaphragmatic



NV - Posttest



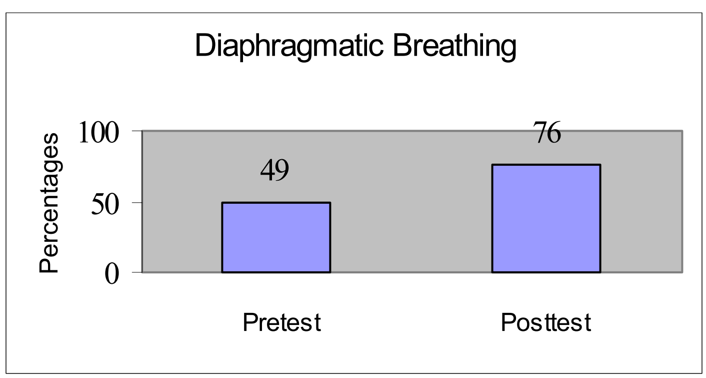


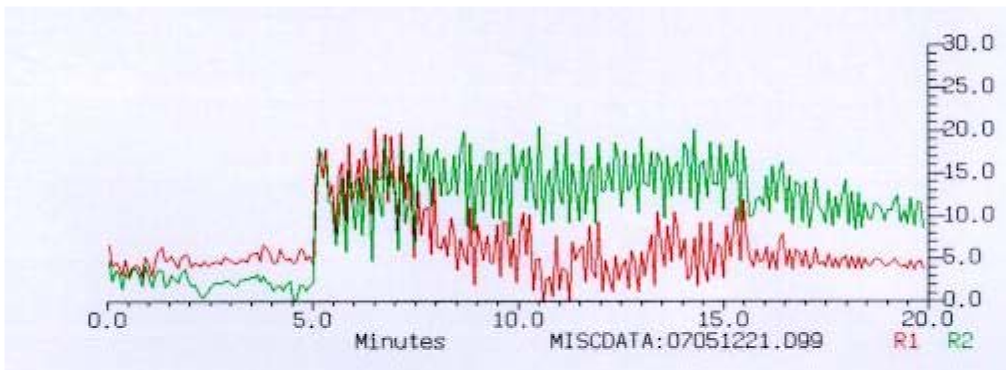
Figure 7. NV – Session 4

NV - Session 4

↓ = General Instructions
∗ = Praise
+ = Response Instructions

Red = Thoracic
Green = Diaphragmatic

↓ + ↓



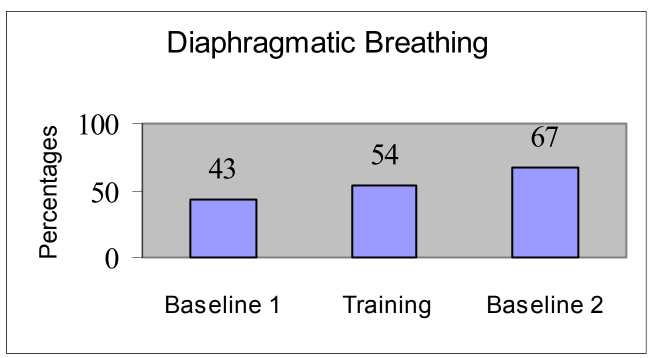


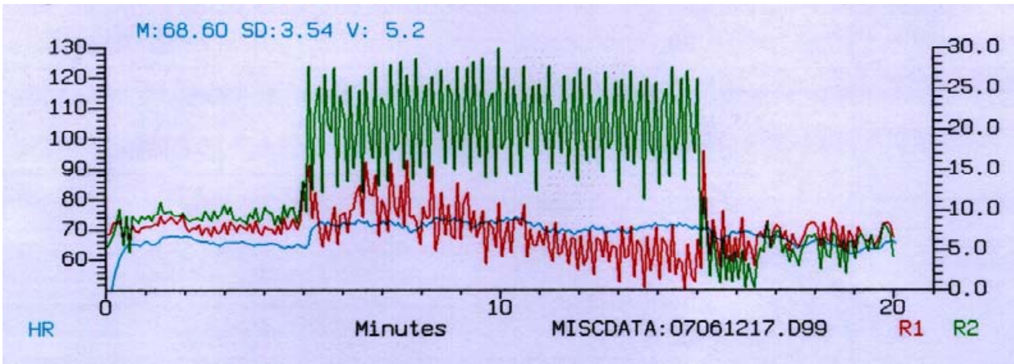
Figure 8. NV – Session 5

NV - Session 5

↓ = General Instructions
∗ = Praise
+ = Response Instructions

Red = Thoracic
Green = Diaphragmatic

↓ ∗ ∗ ∗ ∗ ↓



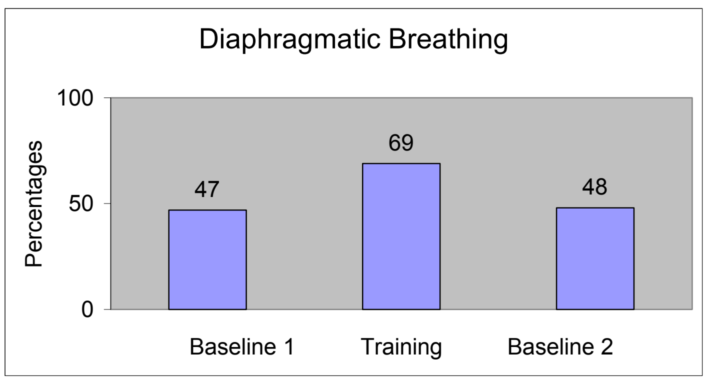


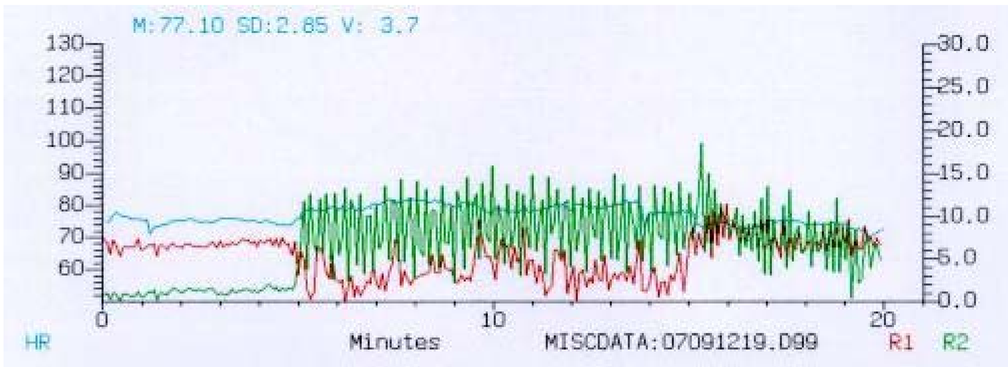
Figure 9. NV – Session 8

NV - Session 8

↓ = General Instructions
∗ = Praise
+ = Response Instructions
# = Interventions

Red = Thoracic
Green = Diaphragmatic

↓ ↓+



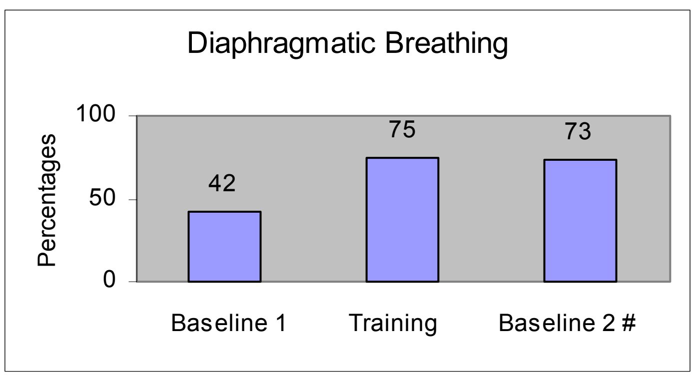


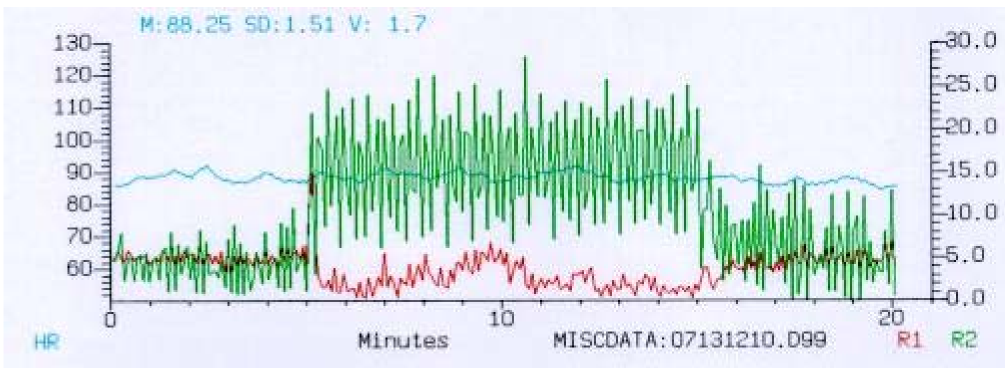
Figure 10. NV – Session 10

NV - Session 10

↓ = General Instructions
∗ = Praise
+ = Response Instructions
# = Interventions

Red = Thoracic
Green = Diaphragmatic

+ ↓ ↓+



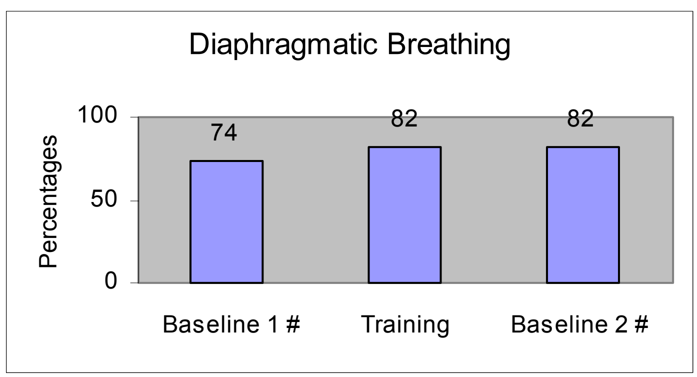
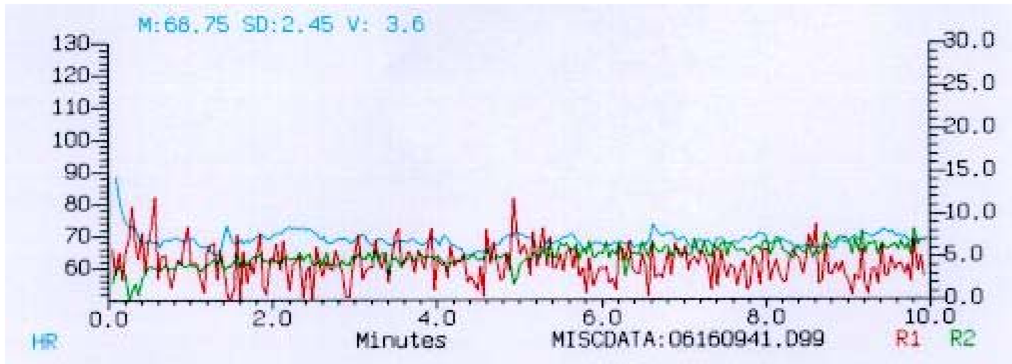


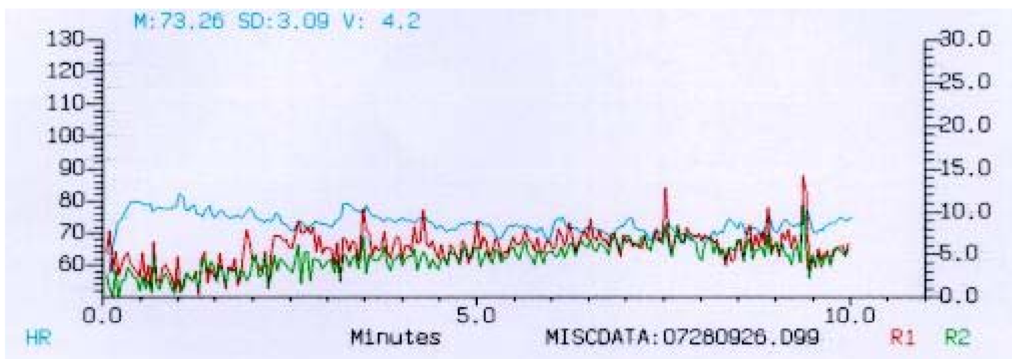
Figure 11. JR – Pretest/Posttest

JR - Pretest

Red = Thoracic
Green = Diaphragmatic



JR - Posttest



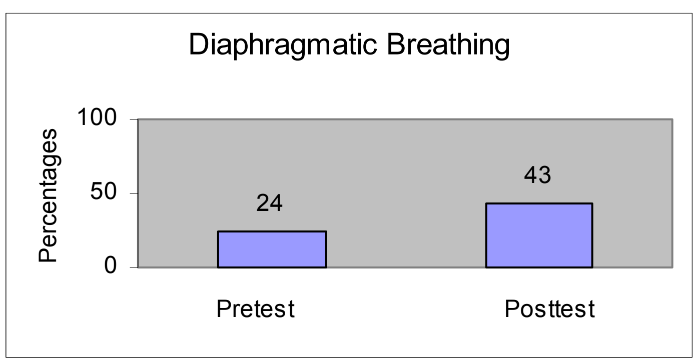


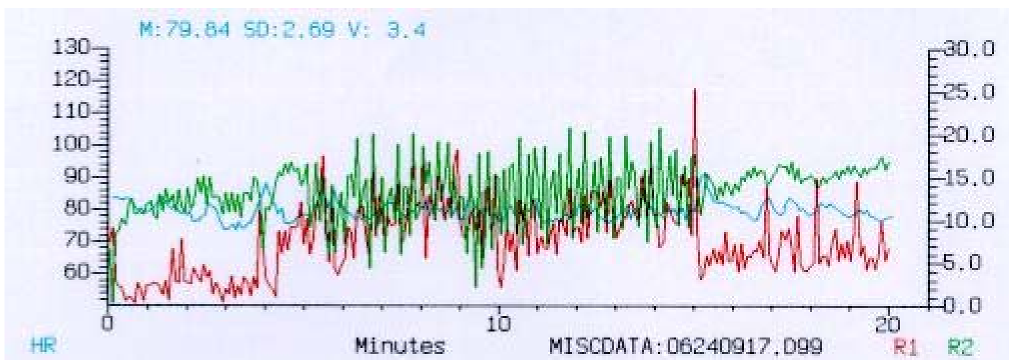
Figure 12. JR – Session 6

JR - Session 6

↓ = General Instructions
∗ = Praise
+ = Response Instructions

Red = Thoracic
Green = Diaphragmatic

↓ + ↓



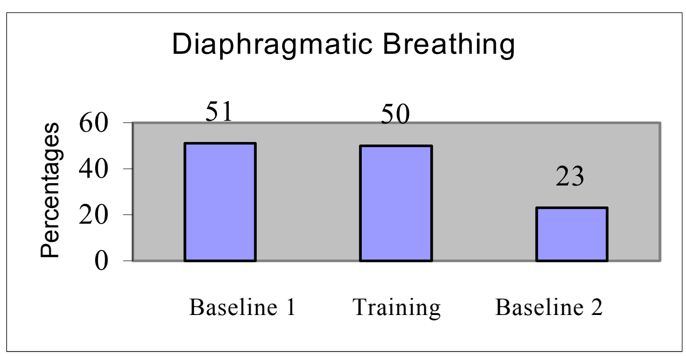


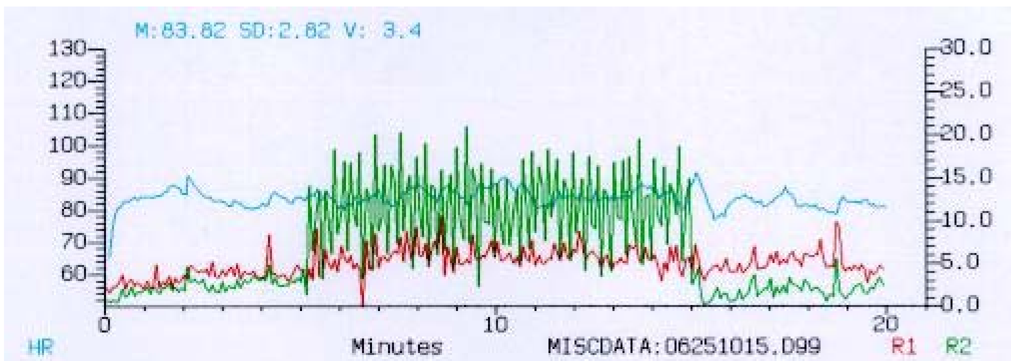
Figure 13. JR – Session 7

JR - Session 7

↓ = General Instructions
∗ = Praise
+ = Response Instructions

Red = Thoracic
Green = Diaphragmatic

↓ ∗ ∗ ∗ + ↓



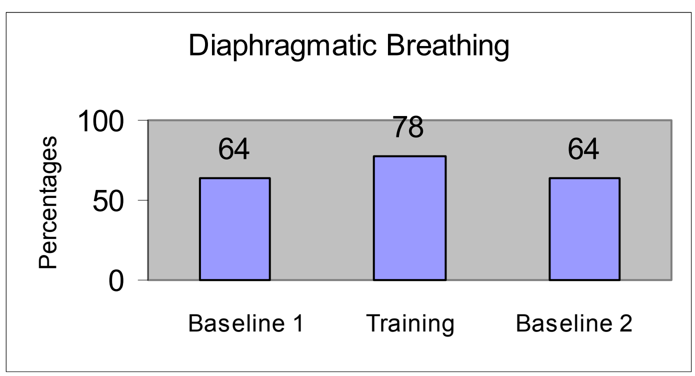


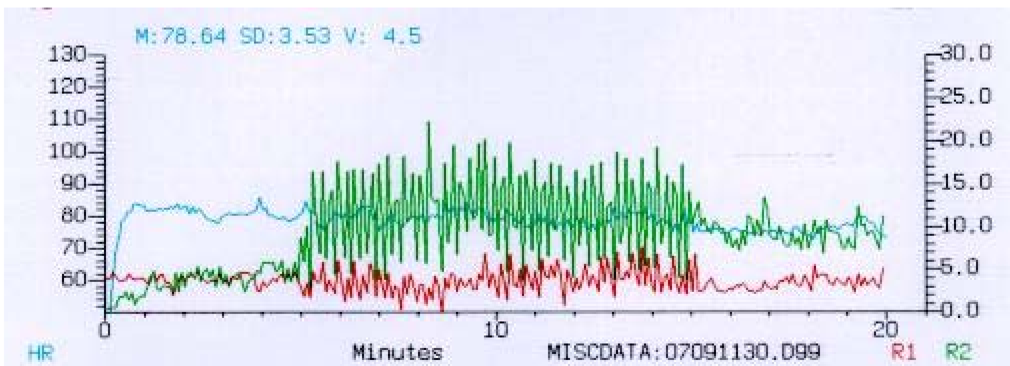
Figure 14. JR – Session 14

JR - Session 14

↓ = General Instructions
∗ = Praise
+ = Response Instructions
# = Interventions

Red : Thoracic
Green : Diaphragmatic

↓ ↓+



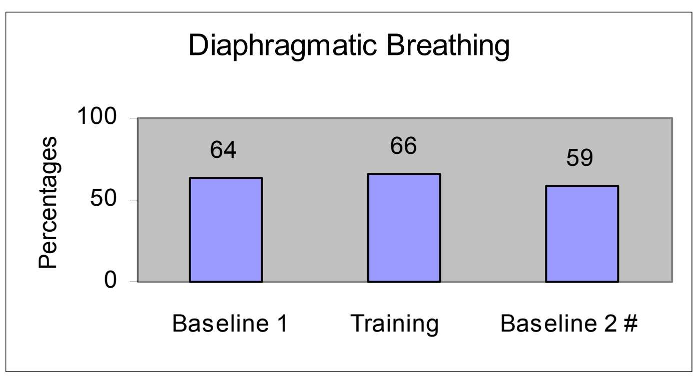


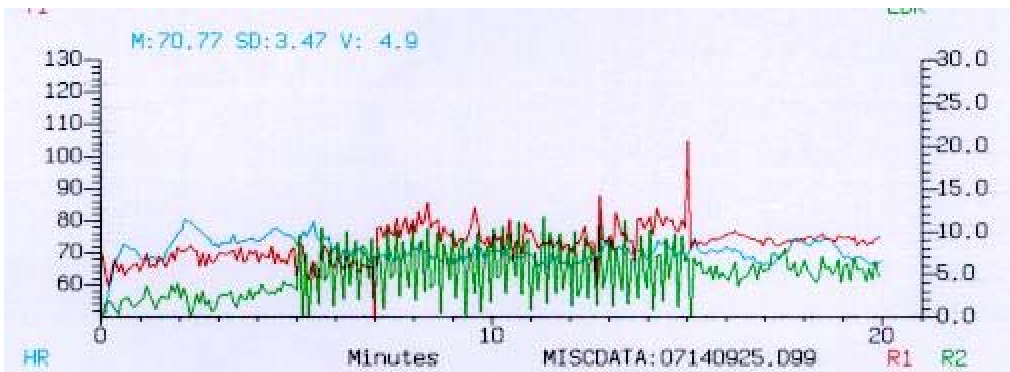
Figure 15. JR – Session 16

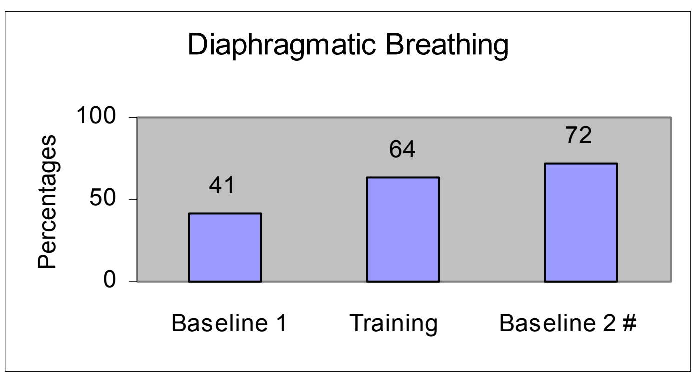
JR - Session 16

↓ = General Instructions
∗ = Praise
+ = Response Instructions
# = Interventions

Red = Thoracic
Green = Diaphragmatic

↓ ↓+ * * * *





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