Applied Psychophysiology Research Team Abstracts

Goedde, J., Kabins, A., Koenig, R., & Shaffer, F. (Faculty mentor) (2007). Patient speech alters respiration rate, blood pressure, and heart rate [Abstract]. *Applied Psychophysiology and Biofeedback, 32*(2), 127.

This study explored the effects of patient speech on respiration rate, blood pressure, and heart rate, utilizing a within-subjects design with complete counterbalancing for order. Fifty-five undergraduates (28 men and 27 women), aged 19-34, volunteered for academic credit. Participants were randomly assigned to one of six orders of three 30-s speech conditions during automated blood pressure measurement, separated by 3-min buffer periods. The three conditions were silence, reading a positive personal health description while breathing continuously and reading the same description while taking as few breaths as possible. An Omega 1400 automated sphygmomanometer measured blood pressure and heart rate, and a ProComp Infiniti system assessed respiration rate. Data were analyzed using a GLM Repeated Measures procedure with Helmert contrasts. The experimental instructions successfully manipulated breath-holding as indexed by respiration rate. Speech decreased respiration rate and increased blood pressure and heart rate compared to silence. Breath-holding slightly amplified these effects on diastolic blood pressure and heart rate. Respiration rate was higher during silence than both speech conditions, $F(1, 49) = 60.9$, $p = .000$, $MD = 3.3$ bpm, and was higher during speech with continuous breathing than with breath-holding, $F(1, 49) = 8.7$, $p = .004$, $MD = 1.1$ bpm. Systolic blood pressure was lower during silence than both speech conditions, $F(1, 49) = 88.4$, $p = .000$, $MD = 11.4$ mm Hg. Diastolic blood pressure was lower during silence than both speech conditions, $F(1, 49) = 174.4$, $p = .000$, $MD = 11.6$ mm Hg, and was lower during speech with continuous breathing than with breath-holding, $F(1, 49) = 7.5$, $p = .009$, $MD = 2.6$ mm Hg. Heart rate was slower during silence than both speech conditions, $F(1, 49) = 101.3$, $p = .000$, $MD = 14.1$ bpm, and was slower during speech with continuous breathing than with breath-holding, $F(1, 49) = 4.4$, $p = .04$, $MD = 2.4$ bpm. We recommend that clinicians not solicit patient conversation when taking these vital signs.
KEYWORDS: white coat hypertension, blood pressure, heart rate.

CITATION PAPER

Kabins, A., Brenner, T., Pacanowski, R., & Shaffer, F. (Faculty mentor) (2007). Validation of a heart rate variability tracking test [Abstract]. *Applied Psychophysiology and Biofeedback, 32*(2), 124.

Tracking tests ensure that physiological measurements mirror client activity. While there are well-established tracking tests for SEMG and temperature, there is no standardized procedure for heart rate variability (HRV). The present study compared the effects of a modified serial-sevens stressor and silence on self-rated stress and four HRV measures (HR max-min, very low frequency amplitude, low frequency amplitude, and high frequency amplitude) using a within-subjects design. Fifty-seven undergraduates (35 men

and 22 women), aged 18-23, volunteered for academic credit. To simulate clinical practice, following 5-min stabilization, participants were randomly assigned to one of two orders of a serial sevens stressor and silence separated by a 2-min buffer period. In the serial sevens condition, they counted backwards out loud from 1000 by 7 for 90 sec. In the silence condition, they sat quietly for 90 sec. Participants sat upright with eyes open in all conditions. A Likert rating scale (1-7) measured self-rated stress. A Thought Technology ProComp Infiniti data acquisition system using Infiniti 2.5 software measured HRV using a PPG sensor placed on the thumb of the nondominant hand. A GLM Repeated Measures analysis found that self-rated stress was higher during the serial-sevens stressor than silence, $F(1, 55) = 243.0$, $p = .000$, eta squared = 0.82. The main findings were that HR max-min, low frequency amplitude, and high frequency amplitude were higher during the serial sevens stressor than silence. HR max-min was higher during the serial-sevens stressor than silence, $F(1, 55) = 15.44$, $p = .000$, eta squared = 0.22. Very low frequency amplitude did not significantly change. Low frequency amplitude was higher during the serial-sevens stressor than silence, $F(1, 55) = 6.67.0$, $p = .013$, eta squared = 0.11. High frequency amplitude was higher during the serial-sevens stressor than silence, $F(1, 55) = 13.63.0$, $p = .001$, eta squared = 0.20. The significant increase of three of four HRV measurements during the serial-sevens stressor supports its use as a tracking test during HRV biofeedback.
KEYWORDS: heart rate variability, HR max-min, tracking tests.

CITATION PAPER

Bax, A., Robinson, T., Goedde, J., & Shaffer, F. (Faculty mentor) (2007). The Cousins relaxation exercise increases heart rate variability [Abstract]. *Applied Psychophysiology and Biofeedback, 32*(1), 52.

Clinicians use Autogenic Training (AT) and the Cousins Relaxation Exercise (CRE) alone and as part of biofeedback training. Since their effects on heart rate variability (HRV) and respiration have been poorly studied, their value as adjunctive exercises in HRV training is unclear. The present experiment compared the effects of AT and the CRE on heart rate variability (HRV) and respiration. Fifteen undergraduates (9 men and 6 women), aged 17-23, participated in this within-subjects experiment. Participants were randomly assigned to one of two orders of relaxation exercises (AT and CRE) separated by a 3-min buffer period. A 3-min eyes-closed resting baseline preceded each relaxation exercise. Participants listened to the recorded 15-min relaxation scripts over loudspeakers while seated upright with eyes closed. A Thought Technology Ltd. ProComp Infiniti system using PPG and respiration sensors measured the standard deviation of the cardiac interbeat interval (SDNN), which is an important indicator of cardiac mortality and morbidity, and respiration rate and amplitude. A General Linear Model procedure for repeated measures revealed that AT did not affect SDNN, respiration rate, or respiration amplitude. In contrast, the CRE increased SDNN, $F\ (1,13) = 5.58$, $p = .034$, $\eta^2 = .30$, slowed respiration rate, $F\ (1,13) = 8.16$, $p = .022$, $\eta^2 = .34$, and increased respiration amplitude, $F\ (1,13) = 11.84$, $p = .004$, $\eta^2 = .48$ compared with the preceding resting baseline. This pattern of physiological change is important since clinicians often attempt to teach patients to slow respiration to a patient's resonant frequency in order to increase

the low-frequency component of HRV and SDNN during HRV biofeedback. These findings support assignment of the Cousins Relaxation Exercise as a home practice exercise to enhance the effects of HRV training with patients who resemble our undergraduates. We recommend that future researchers attempt to replicate these findings with clinical populations.
KEYWORDS: diaphragmatic breathing, effort, SEMG.

Sappington, B., Whipple, J., Pacanowski, R., & Shaffer, F. (Faculty mentor) (2007). Patient conversation raises blood pressure and heart rate [Abstract]. *Applied Psychophysiology and Biofeedback, 32*(1), 59-60.

This study examined the contribution of patient conversation to white coat hypertension. Thirty-six undergraduates and faculty (18 women and 18 men), aged 19-55, simulated patients visiting the campus Health Clinic for a checkup. In this within-subjects design, participants were randomly assigned to one of six orders of three conversation conditions during automated blood pressure measurement, separated by 5-min buffer periods. The three conditions were silence, positive conversation (reading a positive health description), and negative conversation (reading a negative health description). An Omega 1400 automated blood pressure monitor measured blood pressure and heart rate. The PANAS-X measured affect after each blood pressure. A General Linear Model procedure for repeated measures with Bonferonni post hoc comparisons confirmed that the conversation scripts successfully manipulated affect. Positive conversation produced greater positive affect than silence (p = .003) and negative conversation (p = .005). Negative conversation produced greater negative affect than silence (p = .003) and positive conversation (p = .003). Both positive and negative conversations significantly increased systolic (p = .000, M = 11.3 mm Hg; p = .000, M = 10.8 mm Hg), diastolic (p = .000, M = 9.1 mm Hg; p = .000, M = 9.9 mm Hg), and mean arterial blood pressures (p = .000, M = 9.5 mm Hg; p = .000, M = 11.3 mm Hg), and heart rate (p = .000, M = 10.3 bpm; p = .000, M = 9.2 bpm) when compared to silence. Positive and negative conversations produced comparable changes on these measures. Since both positive and negative emotions involve sympathetic activation, patient conversations that result in affective arousal may contribute to white coat hypertension. We recommend that medical professionals control this variable so that readings taken by patients at home and staff during checkups can be meaningfully compared.
KEYWORDS: white coat hypertension, blood pressure, heart rate.

Brotman, J., Lecure, J., & Shaffer, F. (Faculty mentor) (2005). The comparative effects of Autogenics and Cousins relaxation scripts on web dorsum temperature [Abstract]. *Applied Psychophysiology and Biofeedback, 30*(4), 412-413.

There is a continuing controversy concerning whether relaxation scripts incorporating standard Autogenic formulae promote handwarming. The present study compared the impact of two recorded relaxation scripts on web dorsum temperature and self-ratings of calm, enjoyment, activation, and positive and negative affect. Seventeen undergraduates (6 men and 11 women), from 19 to 26 years of age, participated in this experiment. They

listened to recordings of Norman Cousins and Autogenic relaxation scripts during two 45-minute sessions, spaced two days apart, with complete counterbalancing for treatment order. During each session, thermistors were placed over the web dorsum of the dominant hand. Participants sat upright, with eyes closed, stabilized for 15 minutes, and web dorsum temperature was measured 30 s before and after each 14-min script in a 70-degree F room. Following completion of each script, participants rated their calm, enjoyment of the exercise, and positive and negative affect using the PANAS-X. A General Linear Model Repeated Measures procedure revealed that pre-baseline web dorsum temperatures were equivalent for both the Cousins and Autogenic scripts, and there was no order effect. Both relaxation scripts produced handwarming. Pre-baseline to post-baseline temperature increased 3.23 degrees F during the Autogenics script (p = .000) and 1.59 degrees F during the Cousins script (p = .006). The Autogenic script produced greater temperature increases than the Cousins script (p = .047). While the Autogenic script produced greater self-rated psychological calm than the Cousins script (p = .028), there were no differences on self-rated enjoyment, activation, and positive and negative affect. These findings provide additional evidence that listening to a relaxation script incorporating Autogenic formulae can aid handwarming and increase self-rated calm.
KEYWORDS: Autogenic Training, temperature, relaxation.

Copeman, B., Fink, K., Costello, K., & Shaffer, F. (Faculty mentor) (2005). Music can lower heart rate [Abstract]. *Applied Psychophysiology and Biofeedback, 30*(4), 414.

Although undergraduates report that they relax by listening to music, research has not consistently supported this claim. For example, studies have not consistently shown an effect of music tempo on heart rate. The present within-participants experiment compared the effects of no music, and slow and rapid tempi on heart rate. Thirty-seven undergraduates (26 women and 11 men), 18–24 years of age, participated in this study. Photoplethysmographic sensors were placed over the index finger of the dominant hand. Participants wore headphones and sat upright with eyes open, stabilized for 10min, and were randomly assigned to one of six orders of no-music, and slow- and rapid-tempo selections. Each music tempo condition lasted 4 min and was separated by a 4-min buffer period. The rapid-tempo selection was Beethoven's Piano Sonata No. 14 in C Sharp Minor, Walker (2000), track 3, with a tempo of 168 beats per min. The slow-tempo selection was Quitmeyer andWesley's (1999) Musical Journeys, track 2, with a tempo of 60 beats per min. We adjusted the average volume on the Sony CD Walkman so it was comparable for each selection. A General Linear Model Repeated Measures procedure revealed that music tempo significantly affected heart rate (p = .000). Mean contrasts revealed that heart rate was lower during the slow-tempo than the no-music condition (p = .000) and lower during the slow-tempo than rapid-tempo condition (p = .007). There was no difference in heart rate between the rapid-tempo and no-music conditions. These findings support the use of music with a slow tempo to lower heart rate. We recommend that future researchers examine the effect of these music selections on additional autonomic measures.

KEY WORDS: music; relaxation; heart rate.

White, C., Meltzer, M., & Shaffer, F. (Faculty mentor) (2005). Comparison of three tracking tests for BVP and SCL [Abstract]. *Applied Psychophysiology and Biofeedback, 30*(4), 414-415.

Tracking tests ensure the validity of psychophysiological measurements. While tests for sEMG and temperature tracking are well-established, there are many procedures that may be used to evaluate blood volume pulse (BVP) and skin conductance level (SCL) tracking. The present study compared the effectiveness of three popular methods (exhalation of a deep breath, raising and lowering the dominant arm, and abruptly clapping hands behind a participant's head) in changing blood volume pulse and skin conductance level. Twenty-five undergraduates (13 men and 12 women), ranging from 19 to 26 years of age, participated in this experiment. Photoplethysmographic sensors were placed over the first finger, and skin conductance sensors were placed over the second and third fingers of the dominant hand. Subjects sat upright with eyes open, stabilized for 15 min, and were randomly assigned to one of six treatment orders of three tracking tests using a balanced Latin square. Each 30-s tracking test was separated by a 2-min buffer period. A General Linear Model Repeated Measures procedure revealed that each tracking test produced significant changes from baseline and counterbalancing successfully prevented order effects. SCL increased during breathing (15%), arm movement (11%), and clapping (14%). Bonferonni post-hoc comparisons revealed that breathing increased SCL more than arm movement (p = .026) and was equivalent to clapping. BVP also increased during breathing (80%), arm movement (603%), and clapping (84%). Bonferonni post-hoc comparisons revealed that arm movement increased BVP more than breathing (p = .000) or clapping (p = .000). Based on these findings, we recommend that clinicians and researchers use the breathing and arm movement procedures to separately test SCL and BVP tracking or use arm movement to simultaneously test both SCL and BVP tracking.
KEYWORDS: photoplethysmography, skin conductance, tracking tests.

Copeman, B., Lynam, I., Brotman, J., Shaffer, F. (Faculty mentor) (2004). Validation of infrared temperature comparisons between sites on the left and right hands [Abstract]. *Applied Psychophysiology and Biofeedback, 29*(4), 307.

The present study evaluated the concurrent validity of infrared temperature scanning using a single infrared thermometer and whether clinicians may compare measurements obtained from identical sites on both hands. Fifty-three undergraduates (13 men and 40 women) participated in this experiment. The infrared scanning protocol achieved high concurrent validity and allowed valid temperature comparisons between sites on the left and right hands. The authors recommend that clinicians utilize an infrared thermometer to supplement thermistor measurements during assessment and temperature training, and encourage researchers to validate this procedure with clinical samples balanced for age and gender when monitoring the hands and feet.

KEYWORDS: infrared thermometer; thermistor; temperature scanning.

White, C., Lammy, D., & Shaffer, F. (Faculty mentor) (2004). Infrared hand temperature mapping [Abstract]. *Applied Psychophysiology and Biofeedback, 29*(4), 306.

The present study mapped the hand temperatures of undergraduates using a single infrared thermometer at six identical sites on both hands while resting. Fifty-three undergraduates (13 men and 40 women) participated in this experiment. While sites on a single hand and across both hands generally exhibited comparable temperatures, there was a main effect for recording location, which reflected a 0.92◦ F discrepancy between the left and right web dorsum sites. The authors recommend that researchers replicate these findings with a clinical sample balanced for age and gender and clinicians utilize infrared thermometers with the accuracy of clinical-grade thermistors.
KEYWORDS: infrared thermometer; thermistor; temperature scanning.

Shaffer, F., Banks, A., Lipps, A., Franken, F., Giddings, L., Burden, A., & Schwyhart, J. (2003). The comparative effects of position and cordless phone equipment on upper trapezius and cervical paraspinal surface EMG [Abstract]. *Applied Psychophysiology and Biofeedback, 28*(4), 311.

The present factorial experiment examined the effects of position (sitting or standing) and equipment (phone or headset) on upper trapezius and cervical paraspinal sEMG. We studied 43 undergraduate volunteers (9 men and 34 women) using a repeated-measures design. Participants were randomly assigned to five, five-min treatment conditions, separated by 3-min buffer periods. These conditions included baseline, sitting-phone, sitting-headset, standing-phone, and standing-headset. Position and equipment independently influenced trapezius sEMG asymmetry. Equipment also affected cervical paraspinal sEMG asymmetry.
KEYWORDS: sEMG; EMG asymmetry; ergonomics.

Shaffer, F., Banks, L., Lipps, A., Lynam, I., Jacobsmeyer, S., & Rumora, K. (2003). The effects of instructions, sitting position, and task on baseline measurements [Abstract]. *Applied Psychophysiology and Biofeedback, 28*(4), 322.

The present study examined the effect of instructional detail (low-detail or high-detail) and sitting position (upright or reclining) on frontal sEMG, blood volume pulse, heart rate, respiration rate, skin conductance level, and skin temperature. We studied 63 undergraduate volunteers (8 men and 55 women) using a mixed factorial design. All subjects completed the following 3-min conditions: baseline, mental arithmetic, buffer period, baseline, mental arithmetic. Sitting position significantly influenced several psychophysiological measurements, alone and in conjunction with task and instructions. The authors recommend that clinicians standardize this variable so that they may compare measurements within and across sessions.

KEYWORDS: assessment; psychophysiological profile; sitting position.

Shaffer, F., Jacobsmeyer, S., Giddings, L., Sasfai, S., Luebbering, B., & Schlereth, M. (2003) Validation of an infrared temperature scanning procedure for the hands [Abstract]. *Applied Psychophysiology and Biofeedback, 28*(4), 324.

The present study evaluated the concurrent validity of infrared temperature scanning, the reliability of infrared temperature readings taken from six sites on each hand, and whether scanning sequence significantly influenced temperature. Seventy-one undergraduates (16 men and 55 women) participated in this experiment. An infrared thermometer achieved high concurrent validity and reliability, and scanning sequence did not confound temperature measurements. The authors recommend that clinicians incorporate an infrared thermometer in their practice to supplement thermistor measurements during assessment and temperature training, and urge researchers to validate this procedure with clinical populations for monitoring both hands and feet.
KEYWORDS: infrared thermometer; thermistor; temperature scanning.

Shaffer, F., Banks, L., Lipps, A., Franken, F., & Steinman, S. (2002). Ergonomic skin-electrode impedance testing [Abstract]. *Applied Psychophysiology and Biofeedback, 27*(4), 314.

The present study compared the accuracy, speed, and subjective difficulty of impedance testing using test probes and 10-mm cup electrodes. We studied 10 undergraduate research technicians (6 men and 4 women) using a within-subjects design. They measured the skin-electrode impedance of 10-mm silver/silver-chloride surface electrodes placed over the frontales muscles. Although both methods were highly accurate, the cup electrode method was ergonomically superior to the test probe method. It was 27% faster and participants rated it as 35% easier. Therefore, we recommend that professionals who manually test skin-electrode impedance for surface EMG electrodes consider the cup electrode method.
KEYWORDS: impedance testing; ergonomics; sEMG.

Shaffer, F., Lipps, A., Banks, A., Franken, F., & Stokes, C. (2002). Comparison of three surface EMG placements during a psychophysiological profile [Abstract]. *Applied Psychophysiology and Biofeedback, 27*(4), 314.

The present study examined whether the FpN and corrugator placements discriminate as well as the frontalis placement among three typical psychophysiological assessment activities (sitting quietly, performing mental arithmetic, and reviewing recent upsetting experiences). We studied 39 undergraduates (14 men and 25 women) using a within-subjects design. Both the frontalis and corrugator placements discriminated between sitting quietly and two stressors: performing mental arithmetic and reviewing recent upsetting experiences. However, the frontalis placement accounted for more sEMG variability due to assessment condition than did the corrugator placement. These findings are limited to our relatively healthy sample and specific assessment procedures. **KEYWORDS:** psychophysiological assessment; frontalis placement; sEMG.

Shaffer, F., Lipps, A., Banks, L., & Schneider, B. (2002). Effort threatens relaxation training success [Abstract]. *Applied Psychophysiology and Biofeedback, 27*(4), 304.

The present study examined whether relaxation effort influences the physiological effects of brief autogenic and progressive relaxation exercises. We studied 20 undergraduate volunteers (8 men and 12 women) using a within-subjects design, and measured the effects of four 3-min relaxation effort conditions (low-effort autogenic, high-effort autogenic, low effort progressive relaxation, and high-effort progressive relaxation) on accessory sEMG, blood volume pulse, heart rate, skin conductance level, and skin temperature. This study provides preliminary evidence that excessive effort during a brief progressive relaxation exercise increases accessory sEMG activity and skin conductance level, and supports Luthe's emphasis on a relaxed attitude during relaxation training. **KEYWORDS:** autogenic training; progressive relaxation; sEMG.

Shaffer, F., Malone, E., Callahan, C., & Lipps, A. (2001). Is prayer relaxing? [Abstract]. *Applied Psychophysiology and Biofeedback, 26*(3), 246.

This study compared the effects of two forms of prayer (silent Bible reading and silent self-composed prayer) with their secular counterparts (silent reading of a secular passage and silent review of the participant's day) on musculoskeletal (accessory sEMG) and autonomic (heart rate, skin conductance, and skin temperature) variables. Silently composing a prayer significantly lowered accessory sEMG 31% below baseline values, but did not affect any other physiological measurements. Silently reading a Bible passage did not affect any of the monitored variables. The authors encourage further study of the psychophysiological effects of self-composed prayer.
KEYWORDS: prayer; sEMG; religion and medicine.

Shaffer, F., Malone, E., & Krebill, R. (2001). Magnitude statistics can quantify the results of inferential tests [Abstract]. *Applied Psychophysiology and Biofeedback, 26*(3), 230-231.

The value of reporting magnitude statistics, effect size, and proportion of variance accounted for, when presenting inferential test results, was examined. Data from two experiments were used to demonstrate how to calculate effect size (*effect size r* and Cohen's *f* statistic) and proportion of variance accounted for (estimated *omega-squared*) for *t*- and *F*-tests. We showed how these estimates of magnitude can help qualify inferential test results and enable the reader to make better informed judgments regarding

the practical significance of the experimental findings.
KeyWords: magnitude statistics; effect size; estimated omega-squared.

Shaffer, F., Malone, E., Sippely, T., Jos, A. (2001). A revised Truman breathing protocol [Abstract]. *Applied Psychophysiology and Biofeedback, 26*(3), 231.

A revised Truman Breathing Assessment Protocol, which monitors abdominal tension, ETCO2, SpO2, respiration rate, inhalation volume, respiratory sinus arrhythmia (RSA), and accessory sEMG, was described. Patients were evaluated during resting baseline, two stressor (serial-7s and visualization), two activities (talking and typing), and an inspirometer challenge (patients inhaled increasing volumes to detect excessive accessory muscle use). A male undergraduate breathing profile was presented to illustrate how this procedure may be used to assess patients and personalize diaphragmatic breathing training. The authors encouraged clinicians to develop their own protocols to screen for dysfunctional breathing behaviors and develop measurable training goals.
KeyWords: stress profile; breathing assessment; diaphragmatic breathing.

Shaffer, F., Malone, E., & Krebill, R. (2000). How to select the best transformation for psychophysiological data [Abstract]. *Applied Psychophysiology and Biofeedback, 25*(4), 256.

The present study compared the effectiveness of both natural logarithmic and Box–Cox transformations in normalizing EMG values as assessed by the Kolmogorov–Smirnov statistic. Neither the raw scores, $K\text{–}S$ (48) = .201; p = .0001; nor the natural logarithm of these scores, $K\text{–}S$ (48) = .153; p = .007; were normally distributed. Only a Box–Cox transformation produced a normal distribution, $K\text{–}S$ (48) = .119; p = .086; and the least skew. The authors recommend that researchers should select the optimal transformation for a specific data set instead of automatically using a natural logarithmic transformation.
KEYWORDS: data transformation; Box–Cox transformation; Kolmogorov–Smirnov; EMG.

CITATION PAPER

Shaffer, F., Malone, E., Sippely, T., & Callahan, C. (2000). The comparative effects of book bags and carrying styles on upper trapezius and cervical paraspinal surface EMG [Abstract]. *Applied Psychophysiology and Biofeedback, 25*(4), 248.

The present study compared the effects of 3 book bag conditions (backpack, shoulder bag-same side, and shoulder bag-opposite side) on upper trapezius and cervical paraspinal sEMG. The same side condition produced higher preferred-shoulder sEMG levels and greater left–right sEMG asymmetry than that produced by the initial baseline, opposite side, or backpack conditions. We recommend that students avoid wearing a 1-

strap bag on the same side to carry books because this could risk myofascial pain due to prolonged muscle contraction. Instead, we advise using a 2-strap backpack or 1-strap bag on the opposite side to minimize muscular strain.
KEYWORDS: sEMG; EMG asymmetry; ergonomics.

Shaffer, F., Mayhew, J. L., Malone, E., & Hall, J. (2000). A revised survey of undergraduate breathing knowledge [Abstract]. *Applied Psychophysiology and Biofeedback, 25*(4), 256.

This study examined the breathing knowledge of 227 undergraduates because misconceptions about respiratory mechanics can interfere with diaphragmatic training. These students earned a "failing" score of 4.94 out of 12 on the multiple-choice Breathing Knowledge Exam. They had the greatest difficulty with questions that concerned relaxed breathing (goal, respiratory mechanics, and effort used). Participants were grouped into No-Disorder, No-Information, No Disorder-Information, Disorder-No Information, and Disorder-Information categories. An analysis of variance revealed no significant differences in breathing knowledge among these 4 groups. We recommend that health care providers review the factual information they impart to patients diagnosed with asthma and panic disorders.
KEYWORDS: diaphragmatic breathing; breathing knowledge; asthma.

Shaffer, F., Mayhew, J. L., Malone, E., & Miller, K. (2000). Dysfunctional breathing patterns in undergraduates [Abstract]. *Applied Psychophysiology and Biofeedback, 25*(4), 258.

This study screened 326 undergraduates (107 men and 219 women) to measure the frequency of functional and dysfunctional breathing behaviors, using a 37-item Truman Respiration Questionnaire. Most students breathed through their nose (61%). Chest expansion (68%), stomach expansion (56%), and shoulder elevation (52%) were reported during inhalation. Reverse abdominal breathing (28%) and reverse thoracic breathing (10%) were also observed during inhalation. Nine percent of reverse breathers combined both reverse movements. Finally, 25% of students suspended breathing as they stood up quickly. If these findings are replicated at other universities, they would suggest a high prevalence of dysfunctional breathing behaviors.
KEYWORDS: breathing patterns; respiratory disorders; diaphragmatic breathing.

Shaffer, F., Dougherty, J., & Bradley, J. (1999). A survey of undergraduate breathing knowledge [Abstract]. *Applied Psychophysiology and Biofeedback, 24*(2), 135.

Because misconceptions about respiratory mechanics can interfere with diaphragmatic training progress, this study examined the breathing knowledge of 80 undergraduates. These students earned a "failing" score of 4.2 out of 10 on the multiple-choice Breathing Knowledge Exam. They had the greatest difficulty with questions that concerned relaxed

breathing (goal, respiratory mechanics, and effort used) and hyperventilation (respiratory mechanics). When participants were divided into general, prior breathing training, and respiratory disorder groups based on their survey responses, data found that the prior training group had greater breathing knowledge than the respiratory disorder group.
KEYWORDS: diaphragmatic breathing; breathing knowledge; asthma.

Shaffer, F., Mayhew, J. L., Bergman, S., Dougherty, J., & Irwin, D. (1999). Designer jeans increase breathing effort [Abstract]. *Applied Psychophysiology and Biofeedback, 24*(2), 124-125.

This study examined the effect of jean tightness on normal, continuous respiration. Fourteen undergraduates were randomly assigned to either: loose jean, rest, tight jean; or tight jean, rest, loose jean conditions. Jean tightness did not affect tidal volume. However, minute volume increased 11% and oxygen uptake per kg of body weight increased 6% when participants changed from loose to tight jeans. Participants overcompensated for abdominal constriction by increasing minute volume and oxygen uptake. These results support Peper and Holt's guideline that clinicians should encourage patients receiving diaphragmatic training to wear nonrestrictive clothing.
KEYWORDS: diaphragmatic breathing; restrictive clothing; effort.

Shaffer, F., Mayhew, J. L., Bergman, S., Dougherty, J., Koester, A. (1999). Effortful breathing may lower end-tidal CO2 through increased tidal volume [Abstract]. *Applied Psychophysiology and Biofeedback, 24*(2), 124.

This study examined the mechanisms by which high breathing effort reduces end-tidal CO2. Fifteen undergraduates were briefly taught diaphragmatic breathing and randomly assigned to either: low effort, rest, high effort; or high effort, rest, low effort. Respiration rate decreased 28% from low to high breathing effort, tidal volume increased 61%, and the respiratory exchange ratio increased 8%. Tidal volume accounted for 43% of the variance in the respiratory exchange ratio. These results support the explanation that effortful breathing eliminated CO2 through larger tidal volumes and further confirmed the importance of effortlessness and ETCO2 monitoring during diaphragmatic training.
KEYWORDS: diaphragmatic breathing; effort; capnometry.

Shaffer, F., Bergman, S., & Dougherty, J. (1998). End-tidal CO2 is the best indicator of breathing effort [Abstract]. *Applied Psychophysiology and Biofeedback, 23*(2), 127.

This study evaluated six indicators of breathing effort during low and high breathing effort conditions. Fifty undergraduates were taught diaphragmatic breathing and randomly assigned to either: low effort, rest, high effort; or high effort, rest, low effort. Each condition lasted 3 min. A one-tailed *t*-test showed that ETCO2 decreased 14%, accessory sEMG increased 39%, frontalis sEMG increased 120%, SCL increased 13%,

and heart rate increased 4% from low to high breathing effort conditions. Blood volume pulse did not change. ETCO2 was the best overall effort indicator, followed by accessory sEMG. Clinicians should use both indicators to warn of excessive breathing effort.
KEYWORDS: diaphragmatic breathing; effort; sEMG.

Shaffer, F., Bergman, S., & Gannon, L. (1998). Breathing effort depresses end-tidal CO2 [Abstract]. *Applied Psychophysiology and Biofeedback, 23*(2), 128.

This study examined the effects of low and high breathing effort on respiration to test Paper and Holt's thesis that diaphragmatic breathing should be effortless. Fifty undergraduates were taught diaphragmatic breathing and randomly assigned to either: low effort, rest, high effort; or high effort, rest, low effort. Each condition lasted 3 min. A one-tailed *t*-test showed that ETCO2 decreased 14% ($t(49) = 9.10$, $p < .0001$) and ETCO2 variability increased 74% ($t(49) = -5.38$, $p < .0001$) from low to high breathing effort conditions. These results replicated our previous findings and confirmed the importance of effortlessness and ETCO2 monitoring during diaphragmatic training.
Key Words: diaphragmatic breathing; effort; capnometry.

Shaffer, F., Bergman, S., & Henson, M. (1998). Description of the Truman breathing assessment protocol [Abstract]. *Applied Psychophysiology and Biofeedback, 23*(2), 127.

This study standardized a 25-min breathing assessment protocol on 45 undergraduates. The profile measured abdominal excursion, abdominal strain gauge tension, accessory sEMG, ETCO2, inhalation volume, peak flow, respiration rate, and SpO2. Participants were screened for reverse breathing. Peak flow and inhalation volume were then measured. Participants were examined during 3-min serial-7s and visualization stressors, each followed by a 3-min recovery period. Finally, a 3-min inspirometer challenge evaluated accessory muscle use. A representative data record was examined to show how this protocol could help identify dysfunctional breathing behaviors and develop quantifiable training goals.
KEYWORDS: respiration; assessment; stress profile.

CITATION PAPER

Shaffer, F., Bergman, S., & Yochim, B. (1998). Subjective indicators warn against breathing effort [Abstract]. *Applied Psychophysiology and Biofeedback, 23*(2), 108.

This study evaluated three subjective indicators of breathing effort. Forty undergraduates were taught diaphragmatic breathing and randomly assigned to either: low effort, rest, high effort; or high effort, rest, low effort. Each condition lasted 3 min. Regression

analysis showed that ratings of accessory muscle use and breathing loudness predicted 25% of the variance in ETCO2 in the high breathing effort condition ($F\ (2, 37) = 7.65$, $p = .0017$). Ratings of abdominal excursion force were unrelated to ETCO2. Patients should use self-monitoring of accessory muscle use and breathing loudness to warn against excessive breathing effort.
KEYWORDS: diaphragmatic breathing; effort; self-monitoring.

Shaffer, F., Bergman, S., & Hopkins, B. (1997). Breathing effort disrupts diaphragmatic breathing [Abstract]. *Applied Psychophysiology and Biofeedback, 22*(2), 144.

This study tested Peper and Holt's thesis that diaphragmatic breathing should be effortless. We compared the effects of low and high effort diaphragmatic breathing on respiration. Thirty undergraduates were taught diaphragmatic breathing and randomly assigned to either: low effort, rest, high effort; or high effort, rest, low effort. Each condition lasted 3 min. A one-tailed *t*-test showed that high effort decreased ETCO2 11% [$t(29) = 5.65$, $p < .0001$] and increased ETCO2 variability 72% [$r(29) = -3.72$, $p < .0004$] instead of raising and stabilizing ETCO2. These findings confirmed the importance of effortlessness and monitoring ETCO2 during diaphragmatic training.
KEYWORDS: diaphragmatic breathing; effort; capnometry.

Shaffer, F., Bergman, S., & White, K. (1997). Indicators of diaphragmatic breathing effort [Abstract]. *Applied Psychophysiology and Biofeedback, 22*(2), 145.

This study evaluated five indicators of breathing effort during low and high breathing effort instructions. Twenty eight undergraduates were taught diaphragmatic breathing and randomly assigned to either: low effort, rest, high effort; or high effort, rest, low effort. Each condition lasted three minutes. A one-tailed *t*-test showed that accessory muscle sEMG increased 53% from low to high effort, frontales sEMG increased 25%, skin conductance level increased 17%, and heart rate increased 3%. Blood volume pulse did not change. The data suggest that while accessory sEMG was the most sensitive indicator, monitoring all four significant measures may better detect breathing effort.
KEYWORDS: diaphragmatic breathing; effort: sEMG.

Shaffer, F., Mayhew, J. L., Bergman, S., & Gannon, L. (1997). The effect of diaphragmatic training on respiratory homeostasis [Abstract]. *Applied Psychophysiology and Biofeedback, 22*(2), 144.

This study examined whether diaphragmatic training decreases respiratory homeostasis. Twenty undergraduates were assessed on minute volume, respiration rate, tidal volume, and %ECO2 using a metabolic cart during resting and treadmill conditions. Next, they were assigned to a diaphragmatic training (two weekly 60-min group sessions) or control condition, and re-assessed 2 weeks after training. Planned

comparisons revealed that neither diaphragmatic [$F(1, 9) = 0.89$, $p = .37$] nor control group [$F(1, 9) = 0.40$, $p = .557$] treadmill minute volume decreased across this study. Diaphragmatic training did not reduce respiratory homeostasis since ventilation continued to increase with workload.
KEYWORDS: diaphragmatic breathing; paced breathing; homeostasis.

Shaffer, F., Mayhew, J. L., Bergman, S., & Wheelehon, J. R. (1997). Does inhalation-to-exhalation ratio affect diaphragmatic training outcome? [Abstract]. *Applied Psychophysiology and Biofeedback, 22*(2), 145.

This study examined whether inhalation-to-exhalation ratio affects diaphragmatic training outcome. Thirty undergraduates were assessed on minute volume, respiration rate, and tidal volume while resting using a metabolic cart. They were assigned to 1:1 ratio training, 1:2 ratio training, or a control condition, and re-assessed 2-weeks after training. A Student-Newman-Keuls test revealed that the 1:1 ratio group increased %ECO, and tidal volume, and decreased respiration rate more than the control group. The 1:2 ratio group only improved on %ECO2. The two diaphragmatic groups achieved equivalent changes on all measures. We found weak support for favoring 1:1 ratio training.
KEYWORDS: diaphragmatic breathing; inhalation-to-exhalation ratio; respiration.

Shaffer, F., Greve, E., & Parmenter, R. (1996). Validation of a two-session diaphragmatic breathing protocol [Abstract]. *Biofeedback and Self-Regulation, 21*(4), 383.

A previous investigation of our two-session group diaphragmatic breathing protocol validated its effectiveness with healthy undergraduates. The present study attempted to replicate and extend these results. Twelve healthy undergraduates were trained to breathe diaphragmatically during two weekly 60-minute group sessions, and were assigned daily exercises and charting. Inhalation volume increased 79% from 1108 to 1980 millimeters ($p = .005$). Tidal volume increased 51% from 660 to 1000 millimeters. The % ECO2 increased 16% from 3.3% to 3.8% ($p = .005$). Respiration rate decreased 31% from 17.31 to 11.98 breaths per minute ($p = .005$). This study replicated our previous findings and increased our confidence in this diaphragmatic breathing protocol.
KEYWORDS: diaphragmatic breathing; respiration; inhalation volume.

CITATION PAPER

Shaffer, F., Greve, E., & Reinagal, K. (1996). Predictors of inhalation volume [Abstract]. *Biofeedback and Self-Regulation, 21*(4), 352.

Clinicians use an incentive inspirometer to assess diaphragmatic breathing proficiency. This study evaluated the relationship between abdominal excursion, respiration rate, and rib movement, with inhalation volume. Twelve healthy undergraduates were trained to breath diaphragmatically during two weekly 60-minute group sessions, and were

assigned daily exercises and charting. Participants were instructed to breathe diaphragmatically throughout post-assessment. Abdominal excursion was the only measure associated with inhalation volume ($r(11) = .794$, $p < .003$). This study supports emphasis on abdominal excursion instead of respiration rate during diaphragmatic breathing instruction and discourages measurement of rib movement using a cloth tape to evaluate training success.
KEYWORDS: diaphragmatic breathing; respiration; inhalation volume.

CITATION PAPER

Shaffer, F., Greve, E., & Teskey, J. (1996). The autonomic effects of diaphragmatic and thoracic breathing [Abstract]. *Biofeedback and Self-Regulation, 21*(4), 350-351.

Clinicians often incorporate diaphragmatic breathing instruction in stress management programs, believing that a shift from thoracic to diaphragmatic breathing impacts autonomic arousal. This study examined whether diaphragmatic and thoracic breathing patterns produce different autonomic effects. Twenty-four healthy undergraduates were randomly assigned to one of two orders: diaphragmatic breathing, rest, thoracic breathing; or thoracic breathing, rest, diaphragmatic breathing. Measurements were taken for three minutes in each condition. Blood volume pulse (BVP) was 17% higher during diaphragmatic (6.01) than thoracic breathing (5.05) ($t(23) = 2.267$, $p < .0165$). Conversely, skin conductance level (SCL) was 16% higher during diaphragmatic (18.50 μmhos) than thoracic breathing (15.95 μmhos) ($t(14) = 4.19$, $p < .0009$). These findings showed that diaphragmatic breathing produced weak and mixed autonomic effects on phasic measures (BVP and SCL) during a three-minute measurement period.
KEYWORDS: diaphragmatic breathing; respiration; relaxation.

CITATION PAPER

Shaffer, F., Knight, D., & Greve, E. (1996). Autocorrelation discriminates between diaphragmatic and thoracic breathing [Abstract]. *Biofeedback and Self-Regulation, 21*(4), 351.

This study examined whether the autocorrelation of abdominal strain gauge tension values could assess breathing rhythm and discriminate between diaphragmatic and thoracic breathing patterns. Nine healthy undergraduates were trained to breathe diaphragmatically and thoracically during two weekly 60-minute group sessions. Participants were randomly assigned to one of two orders: diaphragmatic breathing, rest, thoracic breathing; or thoracic breathing, rest, diaphragmatic breathing. Strain gauge tension was recorded for three minutes (180 one-second measurements) during each condition. An autocorrelation (with lag 1) of the 180 tension values was calculated for each condition. Each autocorrelation was significant at the .0001 level. Autocorrelation was 73% stronger during diaphragmatic (.759) than thoracic breathing (.438) ($t(7) = - 3.047$, $p < .009$). This study supported clinical use of the autocorrelation of

abdominal strain gauge measurements to evaluate abdominal movement.
KEYWORDS: diaphragmatic breathing; respiration; inhalation volume.

Shaffer, F., Simmons, J., Rever, C., Knight, D., & Rever, A. (1995). An evaluation of nasal and mouth effortless breathing protocols [Abstract]. *Biofeedback and Self-Regulation, 20*(3), 300.

This study replicated a previously validated two-session effortless breathing training protocol and compared the effectiveness of instructions to breathe through the nose or mouth. Following preassessment, 24 healthy undergraduates were matched on respiratory measures and randomly assigned to a two-session nasal breathing group, mouth breathing group, or a control group, which received no training. Participants in the nasal and mouth breathing groups were trained to breathe effortlessly in two weekly 60-minute group sessions and were assigned daily exercises and charting. Control participants received no training and only experienced pre- and post-assessment one week after completion of training. *A priori* orthogonal tests revealed that only the nasal and mouth training groups increased inhalation volume and abdominal excursion, and decreased respiration rate (from preassessment to post-assessment). Nasal and mouth protocols were equally effective. A repeated measures ANOVA showed that these gains were statistically significant. This study validated our two-session effortless breathing protocol and found no selective advantage for nasal or mouth breathing instructions when training healthy undergraduates. We suggest that nasal or mouth breathing should be chosen by patient preference when not dictated by medical concerns.

Shaffer, F., Simmons, J., Rever, C., Knight, D., & Rever, A. (1995). Assessment of a two-Session effortless breathing protocol [Abstract]. *Biofeedback and Self-Regulation, 20*(3), 301.

This report summarizes the effect of our two-session group effortless breathing protocol on 30 healthy undergraduates and identifies predictors of training success. Following preassessment, 30 healthy undergraduates were trained to breathe effortlessly in two weekly 60-minute group sessions and were assigned daily exercises and charted. We repeated the preassessment procedure during post-assessment one to two weeks after completion of training. A repeated measures ANOVA revealed that participants increased inhalation volume and abdominal excursion, and decreased respiration rate. Regression analysis disclosed that preassessment inhalation volume and respiration rate predicted respiratory changes. Finally, a Fisher's r to Z transformation showed that post-assessment inhalation volume was associated with slower respiration and increased abdominal excursion. This study supported clinical use of our effortless breathing protocol with patients who resemble our healthy undergraduates. Training should focus on slowing respiration while increasing abdominal excursion, and may be evaluated using an incentive inspirometer to measure inhalation volume.

Shaffer, F., Knight, D., Lubbe, C., Wehmeyer, T., Stratmann, J., *et al.* (1994). Diaphragmatic training reduces the disruptive effects of common activities on respiration [Abstract]. *Biofeedback and Self-Regulation, 19*(3), 271-272.

The present study explored the effects of routine activities on respiration in 30 healthy undergraduates before and after diaphragmatic training using a within-subjects design. We measured baseline abdominal excursion and respiration rate for 3 min and then randomly assigned subjects to a series of four 3-min activities (reading, writing, talking, and listening) during which we monitored abdominal excursion and respiration rate. After preassessment, we range-matched subjects and randomly assigned them to four 55-min weekly group diaphragmatic training sessions or a no-treatment control group. We repeated the initial screening procedure for both groups during post-assessment. At post-assessment, the diaphragmatic training group achieved greater abdominal excursion during the listening challenge, and lower respiration rate during both challenges, than during preassessment. The no-treatment control group did not improve on any measure. This study showed that these two common activities produced thoracic changes in healthy subjects not trained to breathe diaphragmatically and that diaphragmatic training reduced breathing disruption. We recommend that respiration training incorporate writing and listening challenges to promote generalization.

Shaffer, F., Knight, D., Lubbe, C., Wehmeyer, T., Stratmann, J., *et al.* (1994). The effects of preferred music and volume on undergraduate psychophysiological responses [Abstract]. *Biofeedback and Self-Regulation, 19*(3), 272-273.

Students report using music to stimulate or calm themselves. We explored the effects of preferred music selection (stimulating, calming, and ocean sounds) and volume on physiological responses using a within-subjects design with 30 undergraduates. This question is relevant to behavioral medicine since music exposure may influence cultivation of low arousal, and clinicians employ music in behavioral interventions. We measured baseline values for 3 min. Then, we randomly assigned subjects to one of three music orders for 3 to 5 min each, and recorded data for the first 3 min of each selection. Subjects provided their own selections and adjusted volume to preferred listening levels. We analyzed data for all measures using *a priori* orthogonal tests. Three findings should be emphasized. First, stimulating music produced changes in respiration rate, accessory muscle and frontal EMG, and blood volume pulse and temperature that were inconsistent with cultivated low arousal. Second, calming music did not lower our subjects' physiological arousal. Finally, the ocean selection also failed to lower arousal. We recommend that clinicians consider stimulating music a potential stressor and monitor the effects of "calming" music selections on individual patients before incorporating them in relaxation therapy.

Shaffer, F., Knight, D., Lubbe, C., Wehmeyer, T., Stratmann, J., *et al.* (1994). Validation of two diaphragmatic breathing protocols with healthy undergraduates [Abstract]. *Biofeedback and Self-Regulation, 19*(3), 271.

We developed a group diaphragmatic training protocol in two stages. In Study I, we compared a four-session diaphragmatic protocol against a no-treatment control group using a repeated measures design with 31 healthy undergraduates. After preassessment of abdominal excursion and respiration rate, we randomly assigned subjects to four, 55-min weekly group diaphragmatic training sessions or a no-treatment control group, and then repeated assessment. *A priori* orthogonal tests revealed that the diaphragmatic training group improved inhalation volume, abdominal excursion, and respiration rate, while the control group showed no gains. In Study II, after preassessment that added thoracic movement, we randomly assigned 30 subjects to four-session, two-session, or breathing audiotape groups, and then repeated assessment during midterms. *A priori* tests showed that the four- and two-session groups (which used trained models) comparably increased inhalation volume and abdominal excursion, while they decreased respiration rate from preassessment. The audiotape group only increased abdominal excursion. No group significantly reduced thoracic movement. These studies validated both two- and four-session protocols for teaching diaphragmatic breathing in groups using trained models and demonstrated maintenance of breathing skills 2-3 weeks after training ended during the stress of midterms.

Shaffer, F., Knight, D., Lubbe, C., Wehmeyer, T., Stratmann, J., *et al.* (1994). Comparison of diaphragmatic training methods [Abstract]. *Biofeedback and Self-Regulation, 19*(3), 270.

We compared three diaphragmatic training techniques, which required subjects to place their hands on their chest and stomach while sitting upright (hands); lay a book on their stomach while supine (book); and place one hand on the model's side to match his diaphragmatic breathing pattern (modeling). Study I compared these approaches with 42 healthy undergraduates using a within-subjects design. We measured inhalation volume and respiration rate during preassessment, individually coached subjects in all three methods, and then reassessed. *A priori* orthogonal tests showed that all three methods increased inhalation volume above prebaseline and that modeling produced the highest volumes. These methods also decreased respiration rate below baseline while modeling reduced respiration rate the most. In Study II, we examined 34 healthy undergraduates using a between-groups design to control for progressive error. We added abdominal excursion and thoracic measurements. Modeling improved all four parameters and was superior on all measures except thoracic movement. While the hands and book methods did not significantly affect inhalation volume or respiration rate, the book method increased abdominal excursion, and both hands and book methods reduced thoracic movement. These studies validated the modeling procedure and showed why clinicians must be effective models.

Shaffer, F., Knight, D., Sponsel, M., Belcher, J., Stratmann, J., *et al.* (1993). Vigilance reduces inhalation volume: Nintendo play may reinforce dysfunctional breathing [Abstract]. *Biofeedback and Self-Regulation, 18*(3), 198.

Behavioral factors like posture, accessory muscle contraction, restrictive clothing, and attentional focus can disrupt breathing and produce a faster, shallower thoracic pattern. Video games, which require constant vigilance, may also promote thoracic breathing. The present study assessed the effects of Nintendo play on breathing in 47 healthy undergraduates. We monitored male and female abdominal excursion, respiration rate, and accessory muscle contraction for 4-minute periods in prone and upright positions, at rest and while playing Tetris, a rapid-paced video game in which a player manipulates falling blocks. We predicted that playing Tetris would reduce male and female abdominal excursion, and increase respiration rate and accessory muscle contraction in both positions. A priori mean contrasts confirmed our predictions. These experimental findings have three important clinical implications. First, they show that playing video games can promote accessory muscle tension and thoracic breathing in both males and females. Second, they reveal that thoracic breathing occurs during both prone and seated play. Third, they suggest that playing video games may reinforce dysfunctional breathing in subjects who *already* breathe thoracically and encourage hyperventilation.

Shaffer, F., Krebill, R., & Kice, J. (1993). Double-blind evaluation of a subliminal relaxation audiotape [Abstract]. *Biofeedback and Self-Regulation, 18*(3), 195-196.

Subliminal perception involves the detection and analysis of weak stimuli without awareness. These stimuli are presented at intensities or durations below a dynamically changing signal detection threshold which fluctuates owing to internal noise. The present study assessed the physiological effects of auditory subliminal content on 15 healthy undergraduates using a double-blind design. Subjects received 10 55-min sessions in which they were exposed to either neutral or relaxation subliminal messages while monitored for frontal EMG, hand temperature, skin conductance level, and heart rate. The neutral subliminal slightly lowered frontal EMG across sessions and increased left and right web dorsum temperature both within and across sessions. Within-session changes were small and seen during only 2 of the 10 sessions. No subliminal effects were observed for skin conductance or heart rate. In contrast, the relaxation subliminal audiotape did not reduce arousal on any of the physiological measures within or across sessions. These results, viewed in the context of previous studies, discourage the use of subliminal audiotapes to reduce physiological arousal. Relaxation subliminal audiotapes may be inherently unable to reduce arousal if they operate by increasing vigilance for personally relevant messages like autogenic phrases.

Shaffer, F., Sponsel, M., Knight, D., Belcher, J., Stratmann, J., *et al.* (1993). Attention to the abdomen promotes diaphragmatic breathing [Abstract]. *Biofeedback and Self-Regulation, 18*(3), 197.

Clinicians who teach patients to breathe diaphragmatically routinely ask them to focus on the abdomen, increase diaphragmatic muscle activity while reducing thoracic activity, increase inhalation volume, and slow respiration rate. Instruction to focus on the abdomen reflects the assumption that focusing lower on the body best facilitates diaphragmatic breathing. The present study examined where untrained subjects normally focus attention and the effect on breathing of directing the focus of attention to different body regions. Forty-four healthy undergraduates were monitored for abdominal excursion, respiration rate, and inhalation volume during four randomly presented 3-minute trials in which they passively focused on a body region (mouth, chest, stomach, and feet) with eyes closed. Subjected focused outside these four regions 31% of the time and in descending order, on the chest (28%), abdomen (25%), mouth/nose (13%), and feet (2%). A priori mean contrasts revealed that abdominal focus strengthened more diaphragmatic breathing components than chest focus since it produced the greatest abdominal excursion and decreased respiration rate below baseline. While attention to the feet promoted thoracic breathing in our inexperienced subjects, this focus may distract respiratory patients from areas of concern, like the chest and head, and may help extinguish dysfunctional breathing responses.

Shaffer, F., Sponsel, M., Knight, D., Belcher, J., Stratmann, J., *et al.* (1993). A Double-blind test of brain-wave synchronizer effectiveness in inducing relaxation or alertness [Abstract]. *Biofeedback and Self-Regulation, 18*(3), 196.

Electronic devices that provide audiovisual stimulation emerged in the 1970s and reached the mass consumer market by the early 1990s. This double-blind study assessed the effectiveness of Inner Quest Model IQ-9110 alpha-theta and beta enhancement programs on EEG, autonomic, and respiratory measures in healthy undergraduates. Twenty-four undergraduate psychology students were randomly assigned to one of two coded orders during which they wore eye stimulation glasses and stereo headphones, and experienced both programs. We monitored theta, alpha, and beta amplitude, abdominal excursion and respiration rate, blood volume pulse and heart rate, skin conductance level, and skin temperature during 5-min baselines before and after each audiovisual program, and throughout the 30-min programs. A priori mean contrasts did not support the simplistic assumption that the alpha-theta program produces relaxation and the beta program increases arousal during one session. The two programs did not affect EEG amplitude at the site and frequencies examined. These programs produced similar changes in abdominal excursion, respiration rate, and blood volume pulse consistent with increased vigilance. Decreased skin conductance level and subjective arousal, in contrast, suggested adaptation to sensory stimulation. No changes were observed in heart rate or skin temperature.

Krebill, R., Sponsel, M., Shaffer, F., Duckro, P. N., Schultz, K. T., Belcher, Lewis, M., Hollensbe, J., & Soleman, T. (1992). The impact of EMG transformation on inferential test sensitivity [Abstract]. *Biofeedback and Self-Regulation, 17*(4), 336-337.

Electromyographic (EMG) data are often a skewed (measure of distribution) measurement of muscular activity. Severe skewness violates the assumptions of parametric inferential tests. This violation may decrease the inferential tests' sensitivity to real differences within an experiment group. To modify the data distribution, natural logarithmic ($\log_e$) transformation of the data may provide a more normally distributed data set for statistical comparison. To test this hypothesis, integrated EMG data were collected from 66 undergraduates in two conditions: neutral standing with and without feedback monitoring of left and right trapezius. Data analysis was done with a paired two-tailed *t*-test for correlated measures on raw data means and logarithmic transformed means to assess the impact of feedback. Findings revealed that a feedback effect was only apparent in logarithmically transformed data. The significant difference between the two data sets (raw mean and log transformed mean) was the decrease in skewness of the logarithmically transformed data. The decrease in skewness uncovered a feedback effect that was previously obscured by variability of the raw data. These findings underscore the importance of logarithmic transformation of physiological measurements which are not normally distributed. Data transformation increases inferential test sensitivity and therefore reduces the risk of Type II statistical error.

Shaffer, F., Sponsel, M., Belcher, J., Hollensbe, J., Hart, D., et al. (1992). The chewing gum effect: Imagery disrupts diaphragmatic breathing [Abstract]. *Biofeedback and Self-Regulation, 17*(4), 343.

Researchers have shown that cognitive processes like ideas and imagery affect respiration. It has been demonstrated that negative imagery decreased inhalation volume from baseline values. The present study examined the effects of positive and negative imagery on the breathing patterns of subjects not trained in diaphragmatic breathing. Seventy-two undergraduates were screened by questionnaire for epilepsy and obstructive respiratory disorders. These subjects were randomly assigned to one of two imagery sequences (positive-negative or negative-positive) and assessed during a single 50-minute session. Based on previous research findings, we predicted that negative imagery would produce lower inhalation volume and abdominal excursion, and higher respiration rate than positive imagery. *A priori* mean contrasts supported our predictions. Negative imagery produced significantly lower inhalation volume, less abdominal excursion, and more rapid respiration than positive imagery or the baseline condition. Positive imagery significantly reduced inhalation volume and abdominal excursion compared with the baseline condition. This study replicated earlier findings and revealed a *chewing gum effect* in which attention to imagery disrupts inexperienced subjects' breathing.

Shaffer, F., Sponsel, M., Hollensbe, J., Belcher, J., Knight, D., Sauder, M., & Lewis, M. (1992). Tight shoulders and designer jeans prevent diaphragmatic breathing [Abstract]. *Biofeedback and Self-Regulation, 17*(4), 309-310.

Behavioral factors like posture and clothing tightness can interfere with diaphragmatic breathing. It has been described that the startle response contracts the abdomen and produces shallow, rapid breathing. Researchers have identified a *designer jeans syndrome,* where tight clothing decreases inhalation volume. The present study assessed the relative effects of posture and clothing tightness on breathing in students not trained in diaphragmatic breathing. Thirty-five undergraduates were randomly assigned to one of four orders of shoulder tension and clothing tightness conditions. Accessory muscle EMG and inhalation volume were measured during each one-minute condition. Inhalation volume was calculated immediately afterwards. We predicted that both shoulder tension and tight clothing would reduce inhalation volume. *A priori* mean contrasts supported our predictions, replicating a previous study on designer jeans syndrome with inexperienced subjects. While both shoulder tension and tight clothing reduced inhalation volume separately and synergistically, shoulder tension had a stronger effect.

Shaffer, F., Sponsel, M., Johnson, D., Schenck, C., Wehmeyer, T., *et al.* (1992). The sit-up effect: Acute sitting angles produce thoracic breathing [Abstract]. *Biofeedback and Self-Regulation, 17*(4), 344.

Previous researchers trained asthmatics to voluntarily wheeze by thrusting the head forward and drawing the shoulders in. This raised the question of how sitting posture affects respiration in healthy subjects. Forty-eight undergraduates were screened by questionnaire for epilepsy and obstructive respiratory disorders. They were randomly assigned to one of four posture orders (sit-good, sit-bad, stand-good, and stand-bad). Respiration rate and head and torso angles were measured during each five-minute posture condition. Inhalation volume was calculated immediately after each condition. We predicted that sitting slouched forward would produce greater accessory muscle EMG activity and smaller inhalation volumes than sitting upright. *A priori* mean contrasts supported our predictions. Bad sitting posture decreased torso angle, increased accessory EMG activity, reduced inhalation volume, and accelerated respiration. We have called acute torso angle production of thoracic breathing the *sit-up effect*, since it involves the abdominal compression observed during a sit-up.

Shaffer, F., Sponsel, M., Hollensbe, J., Belcher, J., Lewis, M., & Solomon, T. (1991). Maintenance of diaphragmatic breathing during experimental pain [Abstract]. *Biofeedback and Self-Regulation, 16*(3), 287-288.

Slow, diaphragmatic breathing involves regular excursion of the abdomen with minimal chest movement. Breathing instruction is often included in stress management programs since it counteracts sympathetic arousal produced by hyperventilation (Schwartz, 1987). In the present study, we examined whether a standard diaphragmatic breathing protocol could significantly increase abdominal excursion and reduce respiration rate. Further, we tested whether these changes could be maintained during the stress of experimental pain. Twenty-four undergraduates were matched on respiration rate and randomly assigned to abdominal-thoracic or thoracic-abdominal treatment conditions. Subjects were trained to breathe in abdominal and thoracic patterns during two, 60-minute sessions. During the second session, experimental pain was introduced as a stressor during both abdominal and thoracic breathing exercises. A one-tailed *t*-test revealed that diaphragmatic breathing instruction increased abdominal excursion and reduced respiration rate during breathing practice and experimental pain.

Shaffer, F., Sponsel, M., Kice, J., & Hollensbe, J. (1991). The Effect of auditory feedback on diaphragmatic breathing [Abstract]. *Biofeedback and Self-Regulation, 16*(3), 317.

Several authorities (Fried, 1990; Janis, Defares, & Grossman, 1988) have implicated disordered breathing patterns like hyperventilation in diverse psychophysiological disorders. Slow diaphragmatic breathing, which involves regular excursion of the abdomen with minimal chest movement, corrects abdominal breathing patterns. In the present study, we examined whether feedback of abdominal excursion during breathing instruction would increase excursion more than breathing instruction alone. Eighteen undergraduates, screened by questionnaire for obstructive respiratory or vasoconstrictive disorders, were matched on degree of abdominal excursion and respiration rate, and then randomly assigned to breathing instruction with auditory feedback for abdominal excursion or breathing instruction alone. Subjects were trained to increase the degree of abdominal excursion in two 1-hour sessions. A two-way analysis of variance with repeated measures revealed that diaphragmatic breathing instruction combined with auditory feedback produced significantly greater increases in abdominal excursion than unassisted breathing instruction. Further, only a single 1-hour training session was required in either condition to significantly increase abdominal excursion.

Shaffer, F., Sponsel, M., Kice, J., & Hollensbe, J. (1991). Test-retest reliability of resting baseline measurements [Abstract]. *Biofeedback and Self-Regulation, 16*(3), 317-318.

Behavior therapists monitor biological responses in research and the diagnosis and treatment of medical disorders. Psychophysiological measurements are often recorded during a *resting baseline* at the start of each training session to monitor patient progress within and across sessions. The practice of comparing baseline values across sessions assumes that resting baselines possess acceptable test-retest reliability. This study investigated the temporary stability of six psychophysiological responses (abdominal amplitude, respiration rate, blood volume pulse, hand surface temperature, heart rate, and skin conductance level) recorded over two sessions (days 1 and 8) using 21 undergraduate subjects. Measurement sessions consisted of a 15-min adaptation period, followed by a 5-minute resting baseline condition. Test-retest reliability coefficients were calculated on absolute score values. Five or six reliability coefficients (abdominal amplitude, respiration rate, hand surface temperature, heart rate, and skin conductance level) were statistically significant. These results show that resting baseline measurements can achieve satisfactory test-retest reliability over a standard interval of 1 week between measurement sessions.