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Abstract

Purpose: To determine if there is evidence to support teaching purposeful breathing techniques to patients for the improvement of health outcomes. **Method:** A comprehensive search of literature between 2009 and the present provided 6410 articles of possible interest. A total of 26 met the criteria for inclusion in this review. Two tables were prepared to provide a condensed summary of the significant results. **Findings**: Evidence in the literature supports trained breathing techniques to improve health care outcomes for a variety of issues including anxiety, diabetes, autonomic nervous system disorders, gastro-esophageal reflux (GERD), hypertension, immune function, oxidative stress and pain. **Conclusions:** Teaching breathing techniques provides a simple solution for improving patient health outcomes in a cost effective way in primary care settings. **Recommendations**: Among the forms of breathing techniques studied, teaching diaphragmatic, deep abdominal breathing or specific nostril breathing techniques may be the easiest to teach effectively in a fast paced family practice setting. Other techniques could be provided by developing a simple pamphlet, through a variety of informatics, or formal classroom types of training sessions. **Key words:** breath, breath work, breathing exercises, "breath* technique*" and health*, diaphragmatic, yoga, pranayama, autonomic nervous system, GERD, hypertension, anxiety, diabetes, pain, immunity, oxidative stress.

Breathing Techniques Associated With Improved Health Outcomes

The United States healthcare system produces some of the most expensive health care, while showing an increase in chronic illness and some of the poorest health outcomes worldwide (US Burden of Disease Collaborators, 2013). One major cause of this disparity is the fragmentation of care in the U.S. (Stange, 2009). In a delivery system that emphasizes the human as a commodity, dissected in research, and bartered in politics, individuals lose the ability to integrate wellness options and control their own care (Stange, 2009).

Patients are often frustrated with their care and distrust the perceived lack of personal attention in conventional medicine. Patients are acutely aware of fragmentation and often seek alternative and holistic means to treat their conditions to improve their own health (Nguyen, Davis, Kaptchuk, & Phillips, 2011). For these reasons many patients are seeking more holistic ways to maintain and improve their health (Franzel, Schwiegershausen, Heusser, & Berger, 2013).

Development of safe and cost effective interventions during the office encounter promotes patient self-awareness, self-management concerning health, and potentially improved health outcomes (Edwardson, 2010). Teaching alternative methods such as meditation and breathing techniques, as well as other ancient eastern health modalities, enables the Advanced Practice Nurse (APN) to utilize holistic nursing concepts and offers more options in concert with patients' interests for optimum healing.

According to research by Nahin, Barnes, Stussman, and Bloom (2009), Americans spent $33.9 billion out of pocket on alternative medical treatments in 2007. A recent review of

complementary and alternative medicine (CAM) usage estimated that over 30 million adults spent money on CAM and 7.2 million spent an average of $1385.00 a year on this form of medicine (Davis & Weeks, 2012).

When patients participate in their own health decisions, they tend to be more satisfied with their care. They perceive their own health as improved or excellent, especially when alternative approaches are incorporated (Nguyen et al., 2011). Modalities considered to be integrative or alternative include homeopathic, acupuncture, healers, naturopathy, Ayurveda, chiropractic, osteopathic manipulation, massage, movement therapy, deep breathing, meditation, yoga, relaxation, chakra balancing, hypnosis, Reiki, and therapeutic touch (Nguyen et al. 2011).

In a stratified sample from the 2007 National Health Interview Survey (NHIS), Nerurkar, Yeh, Davis, Birdee, and Phillips (2011), determined that of the CAM type remedies being offered by conventional providers, mind-body therapies (MBT) showed the greatest increase. Of the MBT methods identified, deep breathing exercises were the most common at 84%. The study revealed that conventional providers are increasingly likely to suggest MBT. Of the noted types of MBT, breathing techniques hold promise for the most cost effective, time effective and useful modalities for improving health outcomes (Nerurkar et al. 2011).

Teaching purposeful breathing techniques in the primary care setting may lead to improved health outcomes and patient satisfaction while fostering closer relationships between the patient and the APN. This comprehensive review intends to seek effective breathing techniques and approaches in research that use the breath for the purpose of improving health outcomes. Four breath-related concepts underscore the significance for this project: (a) breath is a natural state of life, (b) breath will change based on environmental and autonomic input, (c)

human beings can consciously alter the breath, and (d) altering the breath can improve health outcomes.

State of the Science

Breath is essential for life. It is regulated by the autonomic nervous system and by cortical input (thought induced) changes (Telles et al., 2013). Both autonomic and cortically induced breathing behaviors are responsive to internal and external environmental stimuli, evidenced by shallow and rapid breathing during episodes of stress. This type of breathing during stress contributes to a potential cascade of symptoms that include anxiety, tachycardia, insomnia, body tension, negative cognition and altered perceptions. Over time, these stress responses can lead to chronic illness such as hypertension, heart disease, chronic fatigue, increased pain perception, changes in hormone levels, and increasing inflammatory markers (Bakal & Davidson, 2013). Breath and patterns of breathing can be changed by the focused and deliberate control of the individual. Purposefully and consciously changing the breathing patterns enables the individual to gain control and provide a positive response to stress (Bakal & Davidson, 2013).

Traditional practices, as documented in numerous historical and contemporary writings, suggest that individual modification of breathing patterns, under the direction and guidance of a teacher, can lead to positive, subjective, affective, cognitive and behavioral changes (Tiwari, Tiwari, Gehlot, & Singh, 2012). These practices provide an opportunity to cope in a more empowered way to life's stresses and improve health outcomes. For instance Fernandes, Nobrega, and Tosta (2012) demonstrated the value of a conscious breathing approach, originating in the yogic practice of pranic (conscious breathing) meditation, by showing improvement in phagocytic function while decreasing the stress hormone, corticotropin. These

chemical changes are considered to be indicators in maintaining and recovering the overall health of the body.

Framework

Rogers' Theory of the Science of the Unitary Human Beings (1970) provided a framework for understanding the value of ancient as well as contemporary methods of the breathing practices for the focus of this review. Rogers (1994) asserts that humans are indivisible and multidimensional energy fields representing more than the sum of their parts. There is an energy exchange between caregiver and patient as well as the human with the environment (Rogers, 1970). Rogers (1992) believed that it is the responsibility of nurses to address the whole human in relationship to the environment, using all forms of knowing from all healing modalities. It is from this theory that nursing can look beyond the conventional walls of current medical paradigms to pull information from all sources historic, foreign, and integrative to assist patients to heal fully.

The act of interacting with patients, moving into their "pattern" or energy field, and finding ways to be both teacher and student in these interactions, has an enormous effect on all involved. It is vital to the healing process. Rogers (1992) wrote that alternative modalities such as meditation and imagery are valuable and worth incorporating in nursing care. In this way, Rogers offered nurses the opportunity to grow in their profession through interacting and teaching from many modalities of healing. Use of breathing techniques, as known from ancient times, is an example of nursing integrating historic knowledge with current research for improved patient health outcomes and potentially self-healing during the training experience.

Methods

Search

For the purpose of this review, a variety of search terms were investigated that would ultimately describe very specific health outcomes related to breathing techniques without other combined healing modalities as might be found within the concept of yoga or mindfulness practices. The databases included in this search were: Medline, PubMed, Cochrane Library, EBSCO-Academic Search Complete, EBSCO-host, CINAHL, CINAHL-Plus, Google Scholar, and Sage Journals Online. Specific journals that tend to incorporate a large portion of complementary and alternative (CAM) articles were evaluated individually. Article references were considered and search terms were sought including: breath, breath work, "breath* technique*" AND health*, breath and health and yoga, prana, Kundalini, chakras, diaphragmatic breathing, breathing exercises, and breath related to specific disease such as gastro esophageal reflux (GERD), hypertension, diabetes, anxiety, pain, stress hormones, cancer, heart disease, immunity, oxidative stress, and autonomic nervous system.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was utilized during the development of this review to provide guidance for the inclusion and exclusion criteria and to enhance transparency related to the research article selection process (Moher et al., 2009). The PRISMA offers a 27-item checklist to organize research, improve consistency of data, critically assess published material, and evaluate interventions. Beyond the transparency of research acquisition offered through the steps of the PRISMA guidelines, the levels of evidence were not provided for each article in the tables due to the wide variety of research modalities used.

Inclusion Criteria

The inclusion criteria focused on any specific breathing techniques and visualization with breathing techniques tested in research that affected detailed change in specific health conditions.

Quantitative, quasi-experimental, systematic reviews, and qualitative studies were included. One hypothesis driven article was also included (Yuen & Sander, 2010). For the purpose of this review, the inclusion criteria accepted articles with varied quality of evidence as necessary for discussion. Although the knowledge and practice of purposeful breathing techniques is thousands of years old, published research articles between the years of 2009 through 2014 were included for the sake of providing the most current research. Only articles written in English and focusing on outpatient settings were included.

Exclusion Criteria

Research articles dated prior to 2009 and inpatient studies were excluded. Studies including multiple modalities of complementary and alternative medicine (CAM) techniques, general terms like yoga, studies where breathing techniques were combined with other modalities, and studies that addressed breathing concerns unrelated to breathing techniques for improved specific health outcomes, were not of interest to this review and were excluded. Any research that did not have a correlation with a specific breathing pattern to specific health outcomes was excluded.

Data Extraction

Three separate database searches using the search terms, yielded 6410 articles. The titles and abstracts were screened for duplicates, and articles were eliminated by use of the inclusion/exclusion criteria. A refined search related to the inclusion criteria of individual health conditions affected by breathing techniques eliminated all but 103 articles in the first sampling. Nine articles remained from the first sample after applying inclusion and exclusion criteria as stated. The retained articles reflect work from the United States, the United Kingdom, Canada, India, and Australia.

A subsequent literature search was conducted with the assistance of a research librarian to assure thoroughness of the investigation and to identify specific health outcomes particular to the proposed comprehensive review. By adding the specific terms "breath* technique*" AND health*, 46 additional research articles were obtained for consideration. From this search, nine more articles were included in this review using the inclusion and exclusion criteria.

A common thread began to emerge regarding the effect of breathing on the autonomic nervous system. This prompted one more search explicitly looking for articles related to breathing techniques and the autonomic nervous system as a specific health outcome. This final search resulted in eight more articles for a total of 26 research articles included for this study.

Data Management and Quality Appraisal

To aid in organization, each of the articles chosen for the review was evaluated thoroughly, and a printed copy of each of those articles was obtained with specific search data hand written on the cover pages. The tables were formulated and specific information from each article placed in the tables in the order they were found. As stated above, the guidelines provided by PRISMA were initiated to aid in transparent reporting of the findings and for structure to ensure adherence to the inclusion and exclusion criteria for this review (Moher et al., 2009).

Synthesis of the Literature Review

Two tables were developed to examine the evidence regarding breathing techniques. The first evidence table (table 1) was developed to synthesize of the literature based on inclusion criteria as stated above. The first evidence table was divided into purpose, study variables, method and design of the study, the condition studied, the type of breathing technique studied, and the outcome of the study.

A second evidence table (table 2) was produced to provide a list of improved health outcomes noted throughout the 26 articles based on teaching breathing techniques. This table also listed the forms of breathing techniques studied as well as the authors of the research for future reference.

Breathing Techniques and Health Outcomes

As noted, the first table describes specific physical outcomes based on teaching breathing techniques. For the purpose of the discussion of this review, the specific physical health outcomes are separated and explained by body systems as related to the process of teaching of all forms of breathing techniques. See table 1 for more detailed explanation of each research article and outcomes.

Cardiovascular

Heart rate and systolic blood pressures were improved with breathing techniques per Anderson, McNeely, and Windham (2010); Bhavanani, Madanmohan, and Sanjay (2012); Sharma et al. (2013); Turankar et al. (2013); and Veerabhadrappa et al. (2011). Diastolic blood pressures were improved as noted by Anderson et al. (2010) and Sharma et al. (2013) but not with Bhavanani et al. (2012). Anderson et al. (2010) noted that long lasting changes in blood pressure were not seen 24 hours after study completion. Mourya, Mahajan, Singh, and Jain (2009) noted improvement in overall blood pressure as well as improvement in the autonomic nervous system parameters.

Pulmonary

Improvement in overall quality of life and exercise tolerance was noted with breath techniques taught for patients with asthma and COPD per Holland, Hill, Jones, and McDonald (2012); Prem, Sahoo, and Adhikari (2013a); and Prem, Sahoo, and Adhikari (2013b). Tiwari et

al. (2012) studied spirometry parameters among diabetics and found an improved overall respiratory rate and slow vital capacity (SVC). The authors suggested the study's findings contributed to the rational for exercise with the diabetic population. Although the study outcomes were not well explained, it did add to the value of teaching breathing techniques. Sayyed et al. (2010) found an improvement in spirometric pulmonary function tests including forced vital capacity (FVC), forced expiratory volume (FEV1), peak expiratory flow rate (PEFR), and maximum voluntary ventilation (MVV). Anderson et al. (2010) noted improved breathing rates. Prem et al. (2013b) performed a systematic review of breathing techniques for asthma and found a significant improvement in quality of life with diaphragmatic breathing compared to medicine management and education. Although the study on smoking cessation by Rawat, Anuradha, Vedamurthachar, Rawat, and Rawat (2011) held promise for strategies to manage this addiction, the specific outcomes of the questionnaire given to subjects was not discussed, making this study inconclusive and not reproducible.

Blood Chemistry

Several studies focused on blood chemistry changes affected by breathing techniques. Martarelli, Cocchioni, Scuri, and Pompei (2011) found improved post prandial insulin levels, decrease glucose levels and improved antioxidant potential, while Jyotsna et al. (2013) found no change in glycemic function. Sayyed et al. (2010) and Subramanian, Elango, Malligarjunan, Vinod and Dayalan (2012) noted improved lipid panel with deep breathing. Subramanian et al. (2010) further noted increased lymphocytes, decreased neutrophils, and decreased platelets as an indication of less stress relative specifically to exam taking. Fernandes et al. (2012) noted improved phagocyte production, decreased corticotropin levels, and improved hydrogen peroxide levels implying less stress with those taught breathing techniques.

Psychological

Although psychological disorders are often interwoven with physical manifestation, it remains worthy of discussion as an individual outcome when addressing the whole human being. Brown, Gerbarg, and Muench (2013) performed a systematic review of several disorders such as anxiety and panic and found that specific breathing practices reduced symptoms. Wollburg, Roth, and Sunyoung (2011) found that teaching increased rate of breath did not increase panic, and was not dangerous for anxiety disorders. Busch et al. (2012) noted that breathing techniques not only alleviate pain, but also improve mood. Joshi, Somyanshi, and Telles (2012) found that specific breathing techniques could improve cognitive function. Stanley, Leither, and Sindelir (2011) and Sharma et al. (2013) noted that perceived stress, anxiety, and fatigue, were reduced with breathing techniques. Dhruva et al. (2012) noted improvement in chemotherapy related quality of life measure such as insomnia, anxiety, fatigue, and depressive symptoms.

Gastrointestinal

A study performed by Eherer et al. (2012) showed improvement in gastrointestinal reflux (GERD) symptoms, improvement in pH, decrease in proton pump inhibitor medication (PPI) use and improvement in quality of life scores. It was noted that at the end of the study time frame, findings were not statistically significant but follow up nine months later showed that those who continued the breathing technique as taught did show significant improvement. This indicates the potential for long-term lifestyle changes having a greater impact on long-term health outcomes.

Neurological

Yuen and Sander (2010) hypothesized from findings in the literature that deep breathing exercises could potentially decrease seizure activity. The authors noted that seizure patients

often had impaired parasympathetic tone and by improving the autonomic nervous system through slow breathing techniques, a decrease in seizures could be possible. These authors recommended research using currently available autonomic nervous system testing strategies to validate this hypothesis.

Data Supported Breathing Techniques

Table 2 was developed to identify the specific types of purposeful breathing techniques found in the literature and the health outcomes associated with these techniques. While general breathing exercises of all kinds offered benefits related to improved health outcomes, the types of breathing techniques in table 2 are helpful for determining training options and for further research regarding specific health outcomes.

Pranayama is a term used to discuss numerous forms of purposeful breathing techniques requiring instructions such as thoracic breathing, diaphragmatic breathing, upper lobe inhalation, lower lobe inhalation, right nostril, left nostril and alternate nostril breathing, three phases including inhalation, holding in the breath, and exhalation, and one study using a breathing technique that was developed specifically for their own study (Dhruva et al., 2012; Fernandes et al., 2012; Prem et al., 2013a; Sharma et al., 2013; Stanley et al., 2011 & Wollburg et al., 2011).

Some unique findings among the types of breathing techniques included specific breathing patterns such as a rhythm of slow, then medium, and then fast rate cycles in sequence and done in repetition (Jyotsna et al., 2013; Rawat et al., 2011; Sayyed et al., 2010; Subramanian et al., 2012; & Veerabhadrappa et al., 2011). A description of two of the more readily trainable forms of breathing techniques is important to discuss.

Diaphragmatic Breathing

Of the breathing techniques studied, diaphragmatic or abdominal breathing and alternate or one-sided nostril breathing offer the simplest teaching opportunities while improving health outcomes. Diaphragmatic breathing techniques involved focusing on the breath with attention to that deep breath by relaxing the abdomen and diaphragm. These deep breathing techniques include developing a pattern of inhalation and exhalation, and slowing each breath by counting, or using a devise to monitor respiratory rate (Bhavanani, Sanjan & Madanmohan, 2011; Busch et al., 2012; Eherer et al., 2012; Martarelli et al., 2011; & Prem et al., 2013a, 2013b). A similar method was described as that which a singer might have been taught during voice lessons (Eherer et al., 2012).

Alternate Nostril Breathing

Several forms and descriptions of breathing techniques by breathing through one nostril or another, while blocking the opposite nostril, hold promise for ease of training and improved outcomes. These methods generally require using a finger or thumb to block a nostril while breathing through the other nostril for a given amount of time (Bhavanani, Madanmohan, & Sanjay, 2012; Dhruva et al., 2012; Ghiya & Lee, 2012; Joshi et al., 2012; Mourya et al., 2009; & Turankar et al., 2013). Of interest for further research, one study suggested that the opposite hemisphere of the brain could be affected by this technique (Joshi et al. 2012).

Breathing Techniques and the Autonomic Nervous System

Evidence revealed a relationship between the autonomic nervous system, breathing techniques and improved health outcomes. Disturbances in the autonomic nervous system have been shown to contribute to cardiovascular disease, diabetes, inflammation, gastrointestinal disorders, chronic stress responses, respiratory changes, and immune changes (Vinik, Erbas, & Casellini 2013). The imbalance of the sympathetic and parasympathetic nervous systems can

also lead to cardiac autonomic neuropathy (CAN) and diabetic autonomic neuropathy (DAN) increasing risk of sudden death, arrhythmias, and silent ischemia. Measuring the autonomic nervous system has become an important predictor of health (Vinik et al., 2013).

The improvement in overall autonomic balance or tone was discussed by Bhavanani et al (2012); Mourya et al. (2009); Sharma et al. (2013); and Yuen and Sander (2010). Sympathetic tone was specifically described by Busch et al. (2012); Jotshna et al (2013); and Turankar et al. (2013). Additionally, improvement in parasympathetic response was described in studies by Bhavanani et al. (2011); Ghiya and Lee (2012); and Veerabhadrappy et al. (2011). Martarelli et al. (2011) correlated improved immunity specifically to the autonomic nervous system.

Recommendations

The evidence suggests that teaching purposeful breathing techniques improves health outcomes for a variety of physical conditions. Further research into all forms of breathing techniques is important. Although adequate patient training is necessary, there is some question whether one particular form of breathing technique is superior to others. Many of the studied breathing techniques required a trainer to facilitate and many of the techniques required significant commitment, repeat lessons, and practice by the subjects thus potentially limiting adherence.

Although numerous methods of training offer effective outcomes, the simplest and quickest forms of breathing techniques may be most valuable for teaching in a busy primary care setting. In order to provide both time and cost effective training opportunities for improved health outcomes, it is important to be able to disseminate the information to the patient efficiently during a typical exam time. Readily reproducible teaching points during the patient visit provide an opportunity for early and lasting improvement in patient health outcomes.

Teaching diaphragmatic, deep abdominal breathing or specific nostril breathing techniques may be the best option during a patient encounter. These specific techniques showed the most cost effective and time effective strategies while improving health outcomes. Diaphragmatic breathing was one of the most studied techniques found in this review and showed important improvement in health outcomes. The alternate nostril or unilateral breathing techniques are of particular interest since these have shown significant changes in several variables related to the autonomic nervous system, as well as improved attention. These breathing technique are also simple to learn, and easier to isolate for research purposes. More research is necessary for both of these forms of breathing techniques. Other beneficial forms of teaching breathing techniques could be provided by a simple pamphlet and accessed through informatics via video and teaching modules, simple phone applications, and formal classroom type of training sessions.

The autonomic nervous system plays a key role in health, wellbeing, and the prevention of illness. Throughout the literature review, the theme of the autonomic nervous system prevailed. Research related to testing the autonomic nervous system in relationship to specific breathing techniques may be of great value.

Conclusion

Patients are seeking Complementary and Alternative Medicine (CAM) modalities to control and maintain their health. They request useful and more holistic tools from their providers, and in turn feel more satisfaction with their health and health care from the providers who offer these options. This review identified significant studies that demonstrated improved changes in health outcomes ranging from immune boosting effects to quality of life improvements as well as positive changes in specific disease processes.

Breathing techniques clearly provide benefits associated with multiple health concerns. Teaching breathing techniques is important for improved health outcomes and for allowing a variety of choices in personalized health care in the primary care setting. This work offers an appreciation of the large variety of forms of breathing techniques for patients to maintain their own health. This comprehensive review offers evidence that providing a simple solution of teaching breathing techniques improves patient health outcomes in a cost effective way and is feasible in the primary care setting.

Although the overarching conclusion to this literature review is that teaching breathing techniques improves health outcomes, more research is necessary to determine which specific breathing techniques are most valuable, simple to incorporate into an office visit timeline, and can be validated by repeated study. Nursing, with the holistic background innate to nursing practice, is uniquely equipped to provide leadership for the implementation of breathing techniques to patients for improved health outcomes.

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Table 1

Studies of breathing techniques and specific health outcomes

Author/ year	Purpose of Study	Study Variables	Method/ Design	Condition being affected by breath-ing technique	Type of breathing technique	Outcomes
Martar-elli et al. (2011)	Determine effects of diaphragm-matic breathing on blood levels	16 athletic cyclists Measuring glucose, insulin, free radicals, antioxidant levels, heart rate	Retrospective study, part of a monitoring program: Blood samples and heart rate Kolmogorov-Smirnov test, two way ANOVA, student-newman-Keuls test p-value <0.05 and post hoc comparison	Measure glucose, insulin, reactive oxygen species (free radicals)	Diaphragmatic breathing: and control described as resting quietly	Significant increase postprandial plasma insulin by ANOVA, significant decrease glucose, decreased biologic antioxidant potential
Jyotsna et al. (2013)	Determine if trained yogic breathing effect on sympathetic function and cardiac *autonomic* function for diabetic patients	64 diabetic patients at endocrine clinic, new pre-diabetic and diabetic patients (Hemoglobin A1C 6-9%), cardiac autonomic function, fasting blood sugar, post prandial blood sugar and Hemoglobin A1C	Randomized controlled interventional trial Cardiac autonomic function Autonomic dysfunction between two groups.one way ANOVA significant as 2-tailed $P < 0.05$	Autonomic neuropathy, diabetes, maximum heart rate variability, cardiac autonomic function, (deep breathing test, Valsalva, sustained hand grip, hand in cold water, lying to standing) blood sugar, post prandial, Hemoglobin A1C	Sudarshan Kriya (SKY) (explained) 24 hours to train SKY Practicing for 6 months	Sympathetic function improved, no change in para-sympathetic function, no change in glycemic parameters
Tiwari et al. (2012)	Determine the value of breathing exercises and	83 diabetic patients, measuring respiratory rate, FVC, SVC after 3 month breathing	Randomized 83 diabetic patients control and exercise groups in diabetic clinic paired sample t-test	Resp. rate, decrease SVC and FVC parameters on spirometry	Kapal, Bhati, Anuloma, Viloma, Deep breathing	Confusing flow in this study, unclear division of control subjects and

	decrease respiratory rate.	training. Spirometric parameters	Unpaired t-test Effect of breathing exercise on FVC		inspiration and expiration	breathing exercise subjects Stated Decrease respiratory rate, decrease in SVC, and FVC in breathing exercise group
Ander-son et al. (2010)	Determine change in breathing patterns and blood pressure with breathing exercises	40 pre or mild hypertensive patients: Blood pressure systolic >130, <160 and diastolic <100, and breathing rate, tidal volume, minute ventilation and end tidal Co2	Randomized procedure practice of device guided breathing taught by machine. Independent two tailed t-test Pre-intervention, intervention, post-intervention Two way ANOVA using Bonferroni multiple comparison tests	Breathing rate, blood pressure, Autonomic nervous system changes, resting blood pressure	Device guided breathing (DGB)	Systolic and diastolic blood pressure lower, decreased breathing rate, tidal volume increased, no change in minute ventilation, no change in PCo2. 24 hour blood pressure not changed
Woll-burg et al. (2011)	Determine change in anxiety based on forced hypo-ventilation or hyper-ventilation as trained	18 control, 31 panic, 32 episodic anxiety Self reported questionnaires after taught to raise or lower CO2	Randomized panic, episodic anxiety, and non anxiety control Variables tested with Kruskal-Wallis, or chi square test. Continuous variables by ANOVA significance set to P < .05 two tailed.	Effect of hypoventilation or hyperventilation testing based on skills taught to subjects. Randomized to either raising or lowering CO2 as measured by capnograph tool (Nellcor)	5 weekly sessions of biofeedback assisted breathing techniques and daily home practice with capnometer	Hyper- and hypo-ventilation produced similar self-reported symptoms and similar to baseline respiratory rate. No improvement or worsening symptoms.
Busch et al. (2012)	Change in pain threshold and	16 university students taught 2 breathing techniques with a 6	Not specified random. 16 subjects: taught two breathing techniques	Pain, mood, autonomic activity through skin	Two succeeding diaphragmatic breathing, Two	Breathing affects autonomic and pain processing.

	mood based on type of breathing technique	month wash out period between training sessions. Measuring mood/autonomic activity, cold pain, heat pain	3 factorial ANOVA effect of the breathing intervention paired student t-test, nonparametric Wilcoxon tests, Cohen's d	conductivity levels POMS profile: a tool to determine mood states	forms of breathing: Attentive deep slow breathing, respiratory rate of 7 cycles per minute. (aDSB) and relaxed deep slow breathing (rDSB)	Skin conductance increased with aDSB (sympathetic) decreased with rDSB Both improved mood and measured less stress
Eherer et al. (2012)	Determine if diaphrag-matic breathing can improve gastro-esophageal reflux disease	19 patients with non erosive GERD or healed esophagitis measuring change in proton pump inhibitor use and quality of life	Prospective randomized controlled study Breathing exercises/ control Study period 4 weeks and voluntary continuation of home breathing techniques use and improvement measured. paired and unpaired t tests	GERD patients on acid reducers Measurements of gastric pH with pH-meter, proton pump inhibitor use, and quality of life measures.	Abdominal breathing techniques per singers (developed by Karl Ernst Hoffman, Austria)	Quality of life symptoms improved after one month training. No changes in pH, no change in structural (LES) relaxation after one month but significant change after 9 months
Fernan-des et al. (2012)	Determine changes in phagocyte and hormone levels related to breath	29 students: 10 wk. training/ blood samples 1st, 5th, 10th week: phagocytosis, hydrogen peroxide, nitric oxide, corticotrophin, cortisol, saliva for melatonin	Pilot study. All subjects given pranayama and blood parameters measured Stats: Friedman's test, Dunn's method for multiple comparisons	Blood phagocytes, hydrogen peroxide, nitric oxide, corticotropin, cortisol, immune function, endocrine changes	Pranic meditation (breathing and visualization), 3 hours per week and home instructions: Greater than 980 minutes invested	Improved phagocyte production, increased hydrogen peroxide, decreased corticotrophin unchanged nitric oxide, cortisol, and melatonin down regulation of hormonal HPA axis.
Brown et al. (2013)	Breathing and GABA pathways,	Breathing techniques related to stress induced emotional	Systematic review of numerous breathing practices. Numerous breathing	Stress, anxiety, insomnia, post traumatic stress	Paced breathing, resonance	Specific breath practices discussed reducing symptoms

	ptsd, panic, anxiety changes with technology assisted interventions	disorders	techniques: review 27 articles with discussion on 13 studies related to technology-assisted devices	disorder, depression, obsessive compulsive disorder, mass disaster, military trauma	breathing, resistance breathing, unilateral nostril breathing, body movement breathing	of numerous types of psychiatric disorders
Mourya et al. (2009)	Effect on breathing exercises on autonomic function	60 patients with stage one hypertension and the affect on the autonomic nervous system	Randomized, prospective controlled study measuring autonomic changes: One way ANOVA, intergroup comparison with unpaired t-test	Autonomic changes with stage one hypertensive patients: heart rate variability, hand grip test, cold pressor response, orthostatic changes	Control, slow breathing exercises, fast breathing exercises.	Improved blood pressure for both fast and slow breathing. Slow breathing improved autonomic function
Dhruva et al. (2012)	Effects of pranayama on cancer associated symptoms and quality of life	18 patients receiving chemotherapy given fatigue analog scale, Karnofsky Performance Status (KPS)	Pilot study to test feasibility of pranayama on cancer symptoms and quality of life. Inform randomized controlled study of 4 breathing practices: T-test for continuous variables and x2 tests for categorical variables	Chemotherapy patients and quality of life, fatigue, insomnia, anxiety	Yoga breathing practices: breath observation, ujjayi breathing, kapalabhati pranayama, nadi shodhana	Dose dependent increase in yoga breathing provided a decrease in cancer-associated symptoms: fatigue, insomnia, anxiety, depression, stress and quality of life
Holland et al. (2012)	Breathing exercises for COPD	16 studies COPD related to breathing exercises: timed breathing, pursed lip breathing, diaphragmatic breathing.	Systematic review: Cochrane approach randomized or quasi-randomized studies. Any technique that altered respiratory pattern	Evaluate reduced breathlessness, increase exercise capacity, and improve QOL	Pursed lips, diaphragmatic breathing, pranayama, technology feedback	Breathing exercises improved exercise tolerance. No consistent improvement of dyspnea or QOL.
Prem et	Comparing	120 patients at out	Randomized controlled trial	Quality of life and	three groups:	Buteyko offered best

al. (2013a)	Buteyko method to pranayama method for change in outcomes with asthma	patient chest medicine clinic: one of three groups: Two types of breathing and control were measured related to quality of life scale	breathing techniques. Descriptive analysis: Kruskal-Wallis test, Bonferroni test, chi-square, Fisher's exact test, pair t-test, Wilcoxon signed rank test.	control of asthma	control, Buteyko, and pranayama (diaphragmatic)	asthma control. Both Pranayama and Buteyko proved significantly better quality of life measures then control
Rawat et al. (2011)	Smoking cessation through Sudharshan Kriya yoga vs pranayama	20 subjects, 3 sequential trained breathing techniques. Slow deep breathing, forced inhalation/ exhalation, slow cycles.	Randomized control: although data not provided. yoga only, VS yoga plus Sudarshan Kriya yoga (SKY) Statistical analysis unknown	Smoking cessation	(SKY) 3 sequential breathing components: ujjayi pranayama, bhastrika pranayama, cyclical breathing	Results of study not given, data not available: yet author concluded that SKY helped reduce smoking habit.
Sayyed et al. (2010)	Evaluating changes in LIPIDS and pulmonary function	55 medical students Blood testing and pulmonary function testing	Randomized 55 subjects. All participants tested pre and post training Blood testing and pulmonary function testing Lab tests before and one week after intervention. Student's paired t test	Lipids changes: prior and after one week, also pulmonary function tested	Sudarshan Kriya (SKY) slow breathing (20 min.), medium breathing (40 min.), fast breathing (40 min.).	Lipid panel: TC, LDL, VLDL, HDL, TG all decreased, HDL increased, significant improvement in pulmonary function
Stanley et al. (2011)	Breathing techniques related to quality of life for patients on hemodialysis	9 Outpatient dialysis units: 126 subjects taught simple long exhalation breathing called holistic breathing	Pilot study: Kidney disease quality of life (KDQOL) instrument: measuring fatigue, pain sleep, overall quality of life Questionnaire pre-post intervention. "Has the breathing technique been	Quality of life measures of end stage renal patients	TOOL: A holistic breathing technique with specific instructions defined in paper	Subjective benefit noted including: relaxing, decreased anxiety, and decreased fatigue. Encouragement from staff improved practicing and

			helpful? And then explain response given in percentages.			outcomes of this breathing technique
Subram-anian et al. (2012)	Role of Sudarshan Kriya (SKY) and pranyama on lipids, and CBC during exam stress	43 engineering students, measuring blood samples based on two forms of breathing: Sudarshan Kriya and pranayama	Randomized study control group and study group measuring pre and post exam stress. Repeated at 3 and 6 week intervals Significance determined by ANOVA followed by Duncan test for multiple comparisons	Lipid profile, complete blood count (CBC), Total Cholesterol, HDL, LDL, TRIG, VLDL	Sudarshan Kriya (SKY) and pranayama This research describes the three part of breath in length	Decrease TRIG, VLDL. LDL and HDL Decrease neutrophils and platelets indicating less stress. Lymphocytes increased indicating improved immunity
Turan-kar et al. (2013)	Evaluating CV function, pulmonary function, galvanic skin resistance within 7 days	11 healthy males: evaluating autonomic nervous system changes from slow deep breathing techniques	Pilot study randomized to slow breathing pranayama or regular breathing Within-group analysis paired t-test inter-group analysis by unpaired t-test	Cardiac function: pulse rate, blood pressure pulmonary function: FEV1 and FVC, galvanic skin resistance (Autonomic nervous system evaluation)	Alternate nostril breathing vs. regular rhythmic breathing. Study methodology described	Significant decrease resting pulse in both groups. Improvement in galvanic skin resistance after standing with intervention group
Joshi et al. (2012)	Determining if alternate nostril breathing increases attention	29 healthy males 5 sessions: right nostril breathing, left nostril breathing, alternate nostril breathing, breath awareness, and control. Related to P300 event in brain discriminating between auditory stimuli and speed of classification of	Randomized study each subject tested in all of five sessions, 20 minutes each session on five separate days: measured with EEG response to auditory clicks Repeat measures by ANOVA. Post hoc analyses for multiple comparisons with Bonferroni adjustment to adjust for risk of false positives.	Peak amplitude and peak latency of P300 assessed from electrode C3, and C4 on EEG. "P300 latency is a measure of cognitive function. Latencies are associated with superior cognitive performance in tasks of attention	Each of 5 different breaths: Right nostril, left nostril, alternating nostril breathing, breath awareness or no intervention	Assessing effect in contralateral brain: P300 peak latency significantly lower at C3 compared to C4 following right nostril yoga breathing.

		stimulus		and immediate memory".		
Sharma et al. (2013)	Determine difference between fast and slow pranayama on perceived stress and cardio-vascular parameters	90 subjects training 30 minutes per day 3 times per week for 12 weeks: three groups: fast breathing, slow breathing or control	Randomized control study Perception of stress (PSS) tool. Kolmogorov-Smirrnov test, one-way ANOVA, and post-hoc analysis by Tukeys-Krammer test. Intragroup comparison by paired t-test, Wilcoxon signed rank test of non-parametric parameter. Chi-square compare intergroup distribution. P<0.5	Perceived stress, diastolic blood pressure (DBP), heart rate (HR), mean arterial pressure (MAP), rate pressure product (RPP), double product (DoP), cardiovascular parameters	Slow (Nadishodhana, Savitri, Pranav) and fast (Kapalabhati, Bhastrika, Kukkuriya) breathing pranayama	Significant decrease in DBP, HR, MAP, RPP, and DoP, improvement in autonomic tone in slow breathing group. Perceived reduction in stress scale (PSS) in both slow and fast breathing
Bhavan-ani et al. (2011)	Sukha pranayama on cardiovas-cular variables with hypertension patients	23 hypertensive patients perform Sukha pranayama for five minutes at 6 breaths per minute.	Pilot study measuring heart rate and hypertension.	Blood pressure, heart rate, pulse pressure mean arterial pressure, Rate pressure product, and double product (measure of myocardial oxygen consumption: DoP) Analysis by student t-test for paired samples	Sukha Pranayama 6 breaths per minute for 5 minutes inhale/ exhale equal count of five each.	Decrease heart rate and systolic blood pressure, Do P, in hypertensive patients Increase parasympathetic and decrease sympathetic activity, improve baro-reflex sensitivity
Bhavan-ani et al. (2012)	Effect of Chandra nadi pranayama (left unilateral forced nostril breathing) on hypertension	22 hypertensive patients left nostril breathing, 6 breaths per minute for 27 rounds.	Randomized study pre-post test, analysis by student's t-test for paired data, Kolmogorov-Smirnov test. P< 0.05.	27 rounds of left nostril breathing on: heart rate, blood pressure, pulse pressure, mean pressure, rate-pressure product, double product (Do	Chandra Nadi Pranayama (left unilateral forced nostril breathing)	Decrease heart rate, systolic pressure, pulse pressure, mean pressure, rate-pressure product, and Do P. No significant change in diastolic pressure,

				P).		Improve autonomic balance
Veera-bhad-rappa et al. (2011)	Effect of yogic bellows (Mukh Bhastrika) pranayama on heart function	50 healthy males related to long term practice of fast pranayama on autonomic balance and heart function	Descriptive Interventional study training 12 weeks with pre and post testing. Analysis done by student's t test.	Autonomic reactivity measured by heart rate, and heart rate response to valsalva maneuver. Heart rate variation to deep breathing difference (DBD). Blood pressure response to standing	12 week training of Mukh Bhastrika (bellows breathing) inhale/exhale quickly 10 times, deep inhalation, few normal breaths. Repeat for three rounds	Pulse rate reduced, heart rate increased to valsalva, heart rate variation increased, increased deep breathing ability. Standing BP reduced. Implying decrease in sympathetic tone, increase in parasympathetic tone
Prem et al. (2013b)	Quality of life regarding asthma and diaphrag-matic breathing	Comparing diaphragmatic breathing and standard asthma education to quality of life with asthma	Systematic review: diaphragmatic breathing related to asthma. 3 studies reviewed	Asthma and quality of life changes based on breathing techniques that included diaphragmatic breathing	Improvement in quality of life with asthma.	Diaphragmatic breathing exercises showed more improvement in asthma quality of life than medications and education..
Yuen et al. (2010)	Determine change in outcome of seizures related to breath work	Discussing slow deep breathing exercises affecting cortical activity and therefore seizure thresholds.	Hypothesis and dialogue from a review of the literature	Seizures related to decrease parasympathetic tone. Discuss autonomic function.	Slow breathing exercises discussed. 6 breaths per minute	Discussion based on stated studies regarding breathing exercises' effect on the autonomic nervous system. Slow breathing exercises may reduce seizure activity.
Ghiya et al.	Autonomic nervous	20 healthy subjects studying two	Subjects randomly performed either paced breathing or	Differences in two techniques of slow	Paced slow breathing and	Both paced breathing and

(2012)	system changes following alternate nostril breathing compared to paced breathing	breathing techniques' effects on heart rate variability by EKG, blood pressure pre and post	alternate nostril breathing for 30 minutes each followed by five minutes of seated rest. Shapiro-Wilk to assess normality of data. Independent t-test to examine variables. ANCOVA to study differences in variables and between different conditions, post –hoc pairwise comparisons with Bonferroni correction	breathing on heart rate variability. Spectral analysis via a software system called Kubios used to analyze the EKG for total power, low frequency power, high frequency power all related to sympathetic and parasympathetic cardiac modulation	alternate nostril breathing techniques	alternate nostril breathing improve the autonomic modulation of the heart reflecting in increase in parasympathetic response.

Table 2

Research supported breathing techniques

Outcomes of teaching a breathing technique	Type of breathing techniques	Authors-years
Improved insulin, decrease glucose, improves pain response, affects sympathetic and parasympathetic response, improve mood, decreased stress, improve GERD symptoms, QOL for asthma.	Diaphragmatic breathing, abdominal breathing	Martarelli et al. (2011); Busch et al. (2012); Eherer et al. (2012); Prem et al. (2013b)
Improved sympathetic function, possible assistance with smoking cessation, improved lipid panel, improve pulmonary function, decrease neutrophils, platelets, increased lymphocytes-immunity.	Sudarshan Kriya (SKY)	Jyotsna et al. (2013); Rawat et al. (2011); Sayyed et al. (2010); Subramanian et al. (2012)
Decrease resting blood pressure, increased tidal volume.	Device Guided Breathing	Anderson et al. (2010)
No changes in anxiety symptoms with biofeedback assisted training. Decrease perception of stress, decrease in diastolic blood pressure, and heart rate, and improved autonomic tone with slow breathing. Hypothesis based on improved autonomic tone to have positive effect on seizures.	Hyper and hypoventilation or fast and slow breathing (pranayama- Slow Nadishodhana, Savitri, Pranav) and fast (Kapalabhati,	Wollburg et al. (2011); Sharma et al. (2013); Mourya et al. (2009); Yuen et al. (2010)

	Bhastrika, Kukkuriya)	
Improved phagocyte production, decreased corticotropin.	Pranic breathing with visualization	Fernandes et al. (2012)
Decrease cancer associated fatigue, insomnia, anxiety, depression, improve quality of life.	Multiple forms of yogic breathing: ujjayi breathing, kapalabhati pranayama, nadi shodhana	Dhruva et al. (2012)
All improved exercise tolerance, no consistent change in quality of life.	Any technique that changed respiratory pattern	Holland et al. (2012)
Improved asthma control, improved quality of life.	Buteyko	Prem et al. (2013a)
Decrease anxiety, fatigue, improved feeling of relaxation.	Breathing techniques developed specifically for this study	Stanley et al. (2011)
Decrease resting pulse, improved galvanized skin resistance (autonomic nervous system response), no affect on attention, improve modulation of heart (heart rate variability) reflecting improved parasympathetic response.	Alternate nostril breathing	Turankar et al. (2013); Joshi et al. (2012); Ghiya et al. (2012)
Improved attention, immediate memory improvement.	Right nostril breathing	Joshi et al. (2012)
Decrease heart rate, systolic blood pressure, improved. parasympathetic tone, decrease sympathetic activity, improve baro-reflex sensitivity.	Sukha pranayama	Bhavanani et al. (2011)
Decrease heart rate, systolic pressure, pulse pressure, improved autonomic balance.	Chandra nadi pranayama	Bhavanani et al. (2012)
Decrease heart rate, improved heart rate variability, decrease sympathetic tone, improved parasympathetic tone.	Mukh Bhastrika (bellows breathing)	Veerabhadrappa et al. (2011)