THE EFFECTS OF YOGA-BASED AND WALKING INTERVENTIONS ON HEADACHES, STRESS, AND ANXIETY

by

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ABSTRACT

ZHANNA DAVID. The effects of Yoga-based and walking interventions on headaches, stress, and anxiety. (Under the direction of Dr. SUSAN K. JOHNSON)

This study examined whether interventions using yoga postures or yogic breathing (YB) can reduce headache frequency and severity, negative physiological and perceived effects of stress, depressive and anxiety symptoms relative to a physical activity (walking) comparison group as well as a wait list control. Participants with no prior yoga experience participated in a four week study that involved training and practice of yoga postures (N = 14), yogic breathing (N = 14), walking (N = 7) or being put on a wait-list (N = 15). Results indicate that while beneficial effects were observed in the three intervention groups, the yoga-based interventions demonstrated greater and consistent level of improvement on the following health measures: headache rate (frequency and severity of headaches), headache-associated difficulties measured by the Headache Disability Index (HDI), anxiety levels measured by the State Anxiety Inventory (SAI), and heart rate, although not all of them reached significance level. Practicing postures and YB for 20 minutes a day, up to 5 times a week for four weeks resulted in the significant drop in perceived anxiety, compared to either walking or control. Additional benefits for headache symptoms and overall physical and emotional health surfaced when only yoga-based interventions were compared to the control. There was a significant decrease in a headache rate for both postures and YB; a significant decrease in bodily pain and interference of pain with normal work, and also a significant increase in energy/decrease in fatigue after practicing postures but not YB. The observed results could represent beneficial effects of yoga-based interventions on headache and pain-related issues, perceived anxiety, some of the cardiovascular variables, and overall level of energy/fatigue. Limitations and suggestions for future research are also discussed.

DEDICATION

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CHAPTER 1: INTRODUCTION

Complementary and alternative medicine (CAM) is defined as "a group of diverse medical and health systems, practices, and products that are not generally considered to be part of conventional medicine" and categorized by the National Center for CAM into four practice-based domains: biologically-based practices, manipulative/body-based practices, energy medicine, and mind-body medicine (nccam.nih.gov). Based on recent surveys, the use of CAM is increasing among US population and various forms of CAM are being used for prevention of health-related issues, management of stress/anxiety, and management of chronic health conditions (e.g. headaches). According to the 2007 National Health Statistics Reports, for example, 38.3% adults in the United States had used CAM in the previous 12 month and 83 million adults spend almost 34 billion dollars of their own money on CAM (Barnes, Bloom, & Nahin, 2008). Mind-body therapy (e.g. meditation, yoga, deep breathing exercises) is one of the most popular categories of CAM used by adults in the US (Barnes, Powell-Griner, McFann, & Nahin, 2004; Barnes, Bloom, & Nahin, 2008). Interest in CAM in general and mind-body treatments specifically is increasing as people search for additional health-management resources and options for treatment as well as a result of biomedical and psychological research progress in identifying the mechanisms by which the mind and body influence each other (Kiecolt-Glaser et al., 2002; Wahben, Elsas, & Oken, 2008). Johnson and Blanchard (2006) investigated CAM and herbal use in University students and identified female gender, older age, modern health worries (e.g., toxins, pollutants), and health-related symptoms, including flu-like, musculoskeletal, and pseudoneurological symptoms as major predictors of student's CAM use. At least one type of CAM was used by 58% of the participants in the past year. Yoga and relaxation were reported among the most frequently used types of CAM. This study also found that prevalence of CAM use was increasing among undergraduates relative to earlier studies.

One of the mechanisms by which mind-body medicine may be influencing health involves interactions between the brain as a part of the central nervous system, various physiological systems (e.g. endocrine, immune, sympathetic/parasympathetic NS), and one's environment (e.g. life stressors) (Vitetta, Anton, Cortizo, & Sali, 2005). Stress-related physiological and psychological issues have a negative impact on both personal and societal levels as stress affects people of all ages, all socio-economic classes, and all educational levels. Stress leads to a hyperarousal of the autonomic nervous system and creates an imbalance between its two branches by increasing activity of the sympathetic nervous system, thus contributing to the interruption of the homeostatic state that is essential for the healthy individual (Rice, 1999). Besides the contribution of stress to serious health conditions such as a weakened immune response (Kiecolt-Glaser et al., 1995; Kiecolt-Glaser et al., 2010), gastrointestinal distress (Levy, Cain, Jarrett, & Heitkemper, 1997), hypertension (Zimmerman & Frochlich, 1990), depression and increased inflammatory response (Maes, 1999), and heart disease (Chandola et al., 2008), stress is associated with a negative effect on chronic pain conditions. For instance, headaches are often associated with stress and anxiety (Dodick, Eross, & Parish, 2003; Powers, Gilman, & Hershey, 2006; Curry & Green, 2007). Stress is considered to be one of the most common triggers for migraine headache and a major factor in progression of headaches from episodic to chronic (Bigal & Lipton, 2008; Houle & Nash, 2008; Robbins, 1994; Sauro & Becker, 2009).

Headache refers to any pain in the region of the head and/or neck. Headaches can be chronic, recurrent, or occasional and the pain can be mild or severe enough to disrupt person's daily activities (nih.gov). Headaches can be classified into two broad categories: primary, which are not the result of another medical condition, or secondary, which can be attributed to some other causative health conditions (Olesen & Steiner, 2004). Primary headaches include tension headache, migraine, and cluster headache and account for 90% of all headaches with first two being most common. According to the National Institute of Health (NIH), the tension-type headache is the most common type of primary headache and can be either episodic or chronic (nih.gov).

Based on previous research, certain types of headache including tension-type and migraine run in families, thus they might have a genetic component (Russel & Olesen, 1995; Russel, 2007). However, environmental factors are an important component of activating any genetic predisposition, including a headache condition. Emotional stress, work or school, tension, neck or back strain due to poor posture are among some of the most common causes of tension-type headache. According to the published estimates of tension-type headache prevalence, the episodic form is affecting 38.3% and the chronic form is affecting 2.2% to 3% of the US population (Rossi et al., 2006; Schwartz, Stewart, Simon, & Lipton, 1998). The tension-type condition has a significant functional impact at work, home, and school (Schwartz et al., 1998).

Migraine is characterized by severe pain intensity on one or both sides with pulsating sensation and is often accompanied by nausea, sensitivity to light and/or sound (Russel, 2007; nih.gov). It affects 29.5 million Americans with higher prevalence among women (17%) compared to men (6%) and potential causes include low blood supply to *meninges* and improper functioning of certain areas of brainstem (e.g. respiration) (Lipton et al., 2007). Stress is the factor listed most often by migraine sufferers as a trigger for their headaches and there is evidence that it may also contribute to migraine chronification (Sauro & Becker, 2009).

Headaches are one of the most common conditions reported by college/university students (Curry & Green, 2006; Smitherman, McDermott & Buchanan, 2011; Souza-e-Silva & Rocha-Filho, 2011).The prevalence of headaches in university students in one cross-sectional study, for example, was 87.2 % with migraine rates of 48.5% and tension-type headache 42.4% (Souza-e-Silva & Rocha-Filco, 2011). Stress and test anxiety are also common among students as academic requirements, life adjustments and pressures in general can be very stressful (Chapell et al., 2005; Conley & Lehman, 2011; Hughes, 2005). Many of CAM techniques, especially ones that include a mind-body component, are often associated with relaxation and therefore can be beneficial for health conditions, such as headache, where stress and anxiety are contributing factors (Wahben, Elsas, & Oken, 2008).

The most commonly used treatment for headaches continues to be pharmaceutical. The pharmaceutical treatment for tension-type headaches consist of analgesic, non-steroidal anti-inflammatory drugs (NSAIDs), and opiate medications (Boline, Kassak, Bronfort, Nelson & Anderson, 1995). Medication for migraine sufferers is divided into two categories: drugs to treat acute attacks and daily drugs to reduce frequency and severity of attacks (preventive) (Goadsby, Lipton, & Ferrari, 2002). Accumulated research shows that some headache sufferers show either not sufficient improvement or adverse side effects from these pharmaceutical treatments, including fatigue, insomnia, gastrointestinal disturbances (Foster & Bafaloukos, 1994), tingling, flushing, dizziness (Goadsby, Lipton, & Ferrari, 2002), weight gain (Boline et al., 1995), and medication overuse (Radat et al., 2007; Bigal et al., 2004). According to Goadsby et al. (2002), out of all migraine patients using preventive medication, only two thirds experience 50 percent reduction in the frequency of headaches. Furthermore, drug therapy is associated with high cost, especially prescription drug therapy. Prescribing medication is a costly treatment that leaves many people medicated with strong pain-killers without sufficient lifestyle benefits. In addition to actual treatment of both acute and chronic headaches, prophylactic treatment of headaches is recommended to reduce the frequency of episodes and reliance on headache pain medications (Relja et al., 2007). It includes dietary changes, improved sleep hygiene, increased activity levels, avoidance of peaks of stress, and use of CAM (Goadsby, Lipton, & Ferrari, 2002).

Another potential medical approach to reduction in frequency of tension-type and migraine episodes, and the prevention of chronic migraines is botulinum toxin (Botox) type A injections. Botox A is considered to be a potent inhibitor of muscle tone and has been used to treat both tension-type headaches and migraines. Results of randomized studies investigating effectiveness of this novel headache treatment are mixed. A statistically significant and clinically meaningful decrease in migraine frequency was observed in Botox A group but not in placebo-treated group (Freitag, Diamond,

Diamond, & Urban, 2008). Dodick and colleges (2010) also found a significant reduction in a headache frequency, headache-related disability, and improved functioning along with overall quality of life in 688 patients who received a series of Botox A injections at seven specific head and neck muscle areas compared to 696 patients who received a placebo. A multicentre, double-blind, randomized, and placebo-controlled study by Relja et al. (2007), however, did not result in significantly greater improvement in frequency of migraine episodes when Botox A was used compared to placebo. There also was no significant difference in resting muscle activity, measured by using serial electromyography, between participants who received Bottox A and participants who received placebo at either 6 or 12 weeks after treatment (Rollnik et al., 2001). Thus, further investigation of efficacy of Botox A injections as a tension-type and migraine headaches treatment is warranted. There are also cost and quality concerns associated with Botox injections as well as access to it as only medical professionals are qualified to administer them.

There is evidence that patients with chronic headache pain seek to integrate CAM into their care as additional resources and options for treatment. For example, headaches are associated with most frequent visits to practitioners of unconventional medicine (Bertisch, Wee, Phillips, & McCarthy, 2009; Rossi et al., 2006). According to the 2007 National Health Interview Survey, about 50% or 13.5 million US adults with migraine/severe headaches reported using at least one CAM treatment within the previous 12 months (Wells, Bertisch, Buettner, Phillips, & McCarthy, 2011). Some of the reasons include the lack of response to conventional therapies, price of conventional treatment, desire to decrease medication intake and pharmacologic treatments, decrease in pain levels, and increase in everyday functioning (e.g. work, school, moving around) (Bertisch et al., 2009; Wells et al., 2011). According to some medical doctors, CAM should be considered by headache patients who also suffer from intolerance to medication, presence of medical contraindications, and who have high stress or poor coping skills (Greb, 2012).

Existing research shows that both, chronic tension headaches and migraines appear to benefit from some of the CAM treatments (Wahben, Elsas, & Oken, 2008), including yoga (Kaliapan & Kaliapan, 1992; John, Sharma, Sharma, & Kankane, 2007), tai chi (Abbot, Hui, Hays, Li, & Pan, 2007), and herbal therapy (Taylor, 2009). Decrease in pain (e.g. intensity, duration, and frequency), increase in energy and ability to carry out usual activities, decrease in medication intake, and improved emotional well-being are some of the reported improvements. In one of the previous national surveys, adults with headaches judged CAM treatments to be more helpful (39.1%) than traditional medical care (19%) for treatment of headaches, and 79% of respondents perceived a combination of conventional therapy and alternative therapies to be better than using either one alone (Eisenberg et al., 2001). Similar results were reported on use of CAM by patients with chronic tension headache. Even though only about 41% of this type of headache sufferers perceived CAM therapies to be beneficial for them, people with chronic tension headache are willing to explore and include CAM therapies into their treatment plans (Rossi et al., 2006).

For example, acupuncture is very often used as a CAM approach to treat migraine and tension-type headaches, but its effectiveness is still controversial (Linde et al., 2009). Linde and colleagues (2005), for example, found that that after 4 weeks of treatments, acupuncture was no more effective than sham acupuncture in reducing migraine headaches in randomized control trial of 302 patients. Both interventions were, however, more effective than a waiting list control.

Research does show that acupuncture appears to have short-term benefits, including decreased number of headache days and pain intensity, but long-term effects are not fully established. Jena et al. (2008) compared almost 3,000 headache sufferers who were randomized into acupuncture and control (wait-listed for 3 months) groups and found that adding acupuncture to a patient's routine medical treatment of migraine and tension-type headaches, reduced the frequency and intensity of pain and improved quality of life. Melchart and colleges (2005) also found that acupuncture reduced the frequency of headaches in 132 patients with tension-type headache compared to 75 patients in the waiting list control after 3 months of treatment. Long-term effects were not fully investigated as both studies did not follow-up beyond 6 months. Acupuncture also can be costly as it requires well trained professionals and more than one session is recommended for lessening headache-related symptoms. Review of previous studies reported the number of sessions being used is between 6 and 15 (Linde et al., 2009). One of the advantages of investigating effect of acupuncture is the feasibility of sham acupuncture that provides an excellent control (Linde et al., 2005).

Another commonly used CAM therapy for migraine with positive results is herbal/nutraceutical treatment, including magnesium (Mauskop, Altura, Cracco, & Altura, 1996) and coenzyme Q10 (Rozen et al., 2002; Sandor et al., 2005), which are involved in many physiological processes including neurotransmitter release, vasoconstriction, and cell energy production. Riboflavin and alpha lipolic acid are two additional supplements that appear to be assisting with mitochondrial dysfunction. It has been proposed that mitochondrial dysfunction play role in migraine pathophysiology by contributing to impaired oxygen metabolism (Lanteri-Minet & Desnuelle, 1996). Vitamin /nutraceutical treatment, however, can be quite expensive, especially when good quality (e.g. natural/food form vs. synthetic form) and/or injections are involved.

As mentioned above, the mind-body medicine category of CAM appears to be one of the most popular: At least one mind-body therapy has been used by over 34 million Americans in 2002 (Bertisch et al., 2008). Furthermore, the use of some mind-body therapies, including deep breathing exercises, meditation, and yoga, increased between 2002 and 2008 (Barnes, Bloom, & Nahin, 2008). Mind-body medicine includes practices that concentrate on interactions between mind, body, and behavior in order to improve physical functioning and overall health (nccam.nih.gov). Yoga is becoming increasingly popular among accepted types of CAM, partially due to its mind-body component and partially due to the fact that there is a minimal risk of adverse effects when yoga is practiced correctly (Evans et al., 2008). According to Johnson and Blanchard (2006), for example, yoga was one of the most frequently used types of CAM among college students. Yoga is a multifaceted and systematic approach to health that has been adopted in the West from ancient Eastern philosophy. Most of the Western adoptions of yoga involve practice of postures, including breath-movement coordination, and/or meditation (Feuerstein, 1998).

The reported benefits of regular yoga practice include physical, mental, and emotional balance which contributes to the feeling of overall well-being, muscular flexibility and strength, increase of parasympathetic and decrease of sympathetic nervous system activity, better pain management, and longevity (Ernst & Lee, 2010; Brown & Gerbarg, 2009; Stuerges, 1997). Yoga has been advocated and investigated as a CAM treatment for a wide range of health conditions, including anxiety (Brown & Gerbarg, 2005; Khalsa et al., 2009; Kirkwood, Rampes, Tuffrey, Richardson, & Pilkington, 2005), chronic pain such as headache (John, Sharma, Sharma, & Kankane, 2007), fibromyalgia (Carson et al., 2010), back pain (Sherman, Cherkin, Erro, Miglioretti, & Deyo, 2005), and stress (Brown & Gerbarg, 2005; Kielcolt-Glaser et al., 2010; Raghuraji & Telles, 2008; West, Otte, Geher, Johnson, & Mohr, 2004).

Stress prevention, including yoga-based techniques, has been addressed by a number of researchers (Brown & Gerbarg, 2005; McEwen, 2008; Waelde, Thompson, & Gallagher-Thompson, 2004). Previous research on yoga as a potential stress-reduction and anxiety management intervention has concentrated mainly on its meditative component (Bishop, 2002; Cahn & Polich, 2006) and postures (Kiecolt-Glaser et al., 2010; Lee, Mancuso, & Charison, 2004; Smith, Hancock, Blake-Mortimer, & Eckert, 2007; Streeter et al., 2010; West et al., 2004). One of the other important components of Classical Yoga is pranayama or yogic breathing (YB). There are just a few studies investigating the effect of YB on health outcomes, including stress and anxiety (Gupta, Kumar, Kumari, & Deo, 2010; Kozasa et al., 2008; Raghuraj & Telles, 2008; Subbalakshmi, Saxena, Urmimala, & D'Souza, 2005). YB, according to a neuro-physiologic model of yogic breathing, uses the autonomic nervous system as the gateway for access to the neural centers (Brown & Gerbarg, 2005). Previous research shows that slow and deep YB and concentration on the process of breathing, has a calming effect on the human mind by decreasing the sympathetic and increasing parasympathetic nervous system activity (Raghuraj & Telles, 2008).

Pranayama (YB), Stress Reduction, and Headache Pain.

Traditionally, pranayama/YB is a set of breath controls that integrates mental focus (e.g. counting, attentiveness to air flow) with the control of airflow while also employing a variety of controlled muscular contractions (Feuerstein, 2001). Thus, it includes mental and mechanical components. YB requires the conscious use of the structural parts of the breathing system (e.g. diaphragm), which is accompanied by specific observable movements (e.g. stomach, shoulders). YB characteristics include slow and deep breathing following a specified ratio (e.g., 1:2:2), doubling of the exhalation time compared to the inhalation time, and fast forced breathing. Variations of YB differ and include techniques such as full abdominal breath, bastrika with forced inhalation and exhalation, alternate nostril breathing (*nadi shodhana*), and alternate nostril breathing with breath retention known as *anuloma viloma* (Sturgess, 1997). The speed of respiration, the ratio used, and the length of each session in addition to the overall practice length are variables that contribute to the purported physiological and psychological effects in YB users, including decreased heart rate, blood pressure, stress, and anxiety (Abel, Lloyd, & Williams, 2013; Burke & Marconett, 2008; Jerath et al., 2006).

YB has been proposed as one of the approaches for adjusting imbalances in the autonomic nervous system by shifting away from its sympathetic (excitatory) dominance and, thereby ameliorating the negative effects of stress (Brown & Gerbarg, 2005; Novotny & Kravitz, 2007; Sovik, 2000). Calming of stress response systems, including increased parasympathetic drive and neuroendocrine release of hormones, are feasible YB mechanisms contributing to a state of calm alertness (John et al., 2007).

Two other possible mechanisms explaining the effect of YB on autonomic nervous system functioning have been proposed. According to Brown and Gerbarg (2005), a systemic shift occurs during YB as parasympathetic nerve activity overrides sympathetic nerve activity via stimulation from vagal somatosensory afferents in the glottis, pharynx, lungs, and abdominal viscera.

According to the cellular mechanism of pranayama proposed by Jerath et al. (2006), deep YB alters the autonomic nervous system by increasing both frequency and duration of inhibitory neural impulses via activation of slowly adapting stretch receptors (SARs). Inhibitory impulses produced by SARs in the lungs during inhalation contribute to autonomic functions such as systemic vascular resistance and HR (Schelegle & Green, 2001). In addition, YB increases stretching of connective tissue (fibroblasts) around lungs which contributes to heightened generation of hyperpolarization current. Hyperpolarization current has been associated with parasympathetic-like changes, including relaxation of vascular smooth muscle (Kamkin, Kiseleva, Lozinsky, & Scholz, 2005; Tare et al., 1990). Jerath et al. (2006) hypothesize that both, inhibitory impulses and hyperpolarization also contribute to synchronization of neural elements in the central nervous system, peripheral nervous system, and surrounding tissues and that eventually leads to increased parasympathetic dominance.

Previous studies that investigated YB either as a single intervention or in combination with postures and meditation have demonstrated some effects on stress related variables such as blood pressure (BP) and heart rate (HR) (Raghuraji & Telles, 2008; Sabbalakshmi et al., 2005), self reported anxiety (Kozasa et al., 2008), and headache-related symptoms (John et al., 2007; Kaliappan & Kaliappan, 1992).

Subbalakshmi et al. (2005), for instance, investigated whether 20-minutes of alternate nostril YB had any immediate effect on problem-solving abilities, HR, systolic blood pressure (SBP), and diastolic blood pressure (DBP) as cardio-vascular and parasympathetic nervous system variables. Ten healthy subjects between 17 and 20 years old and without any previous training in YB, volunteered for the experimental condition. An additional 20 participants were selected and randomly assigned to control groups A (relaxing on the couch) and B (quiet normal breathing/eyes closed). A significant decline in HR and SBP were observed in ten participants after one session of alternate nostril YB practice for 20 minutes, but not in two sets of controls. Furthermore, it took participants significantly less time in solving simple arithmetic problems immediately after alternate nostril YB session compared to the time taken for solving problems prior to the training (Subbalakshmi et al., 2005). Subbalakshmi et al. (2005) speculated that these results could be due to better adaptability to mental stress induced by breathing activity for 20 minutes.

Raghuraj and Telles (2008) investigated the effect of right nostril YB, left nostril YB, and alternate nostril YB on autonomic and respiratory variables compared with breath awareness and normal breathing (control). Twenty one male participants between 18 and 45 years of age were randomly assigned to five fixed possible sequences of right nostril YB, left nostril YB, alternate nostril YB, and normal breathing that were performed on five different days for 30 minutes each session. The SBP and DBP decreased in participants after performing alternate nostril YB, the SBP decreased after left nostril YB, and the skin conductance increased after right nostril YB (Raghuraj & Telles, 2008). The authors suggested that each YB technique is associated with distinct autonomic changes.

Kozasa et al. (2008) investigated effects of *Siddha Samadhi* yoga in which meditation is associated with YB, on anxiety and depressive symptoms. Twenty two participants with anxiety complaints were randomly assigned to either a yoga group (*n* = 14) or a waiting-list control (*n* = 8) group. The *Siddha Samadhi* yoga program (YB and mantra-meditation) lasted two weeks and both, YB and meditation were advised to be practiced for 20 minutes each, twice a day. The STAI, the Beck Depression Inventory (BDI), the Tension Feeling Self-evaluation Scales, and the Well-being Self-evaluation Scales were administered before the intervention and one month after the intervention ended. A significant reduction in anxiety, depression, and tension was reported by the yoga group relative to controls. Well-being scores are also increased in the yoga group but not in the control.

Previous research shows that headaches are often associated with stress and anxiety (Curry & Green, 2006; Dodick, Eross, & Parish, 2003; Powers, Gilman, & Hershey, 2006). Emotional stress is one of the causes of tension-type headache. Stress is considered to be one of the most common triggers for migraine headache and a major factor in the progression of headaches from episodic to chronic (Bigal & Lipton, 2008; Houle & Nash, 2008; Robbins, 1994; Sauro & Becker, 2009). Although our autonomic nervous system regulates breathing, we can manipulate the rate at which we breathe, the amount of breath inhaled and exhaled, and we can hold our breath for a short period of time. In turn, moderating our breath can enable us to better manage stress by helping lower sympathetic nervous system activity. Thus, by reducing physiological and perceived effects of stress/anxiety, YB might indirectly reduce headache-related symptoms.

Yoga Postures, Autonomic Nervous System, and Headache Pain.

The benefits of exercise for management of stress/anxiety and pain conditions have been long recognized by both medical doctors and the scientific community (Evans et al., 2009; Salmon, 2001). Exercise affects musculoskeletal (Sjogren et al., 2005), cardiopulmonary functioning, improves mood (Greenwood & Fleshner, 2008), appears to decrease headache pain severity/ intensity (Lockett & Campbell, 1992; Sjogren et al., 2005), and impacts brain chemistry to regulate central somatomotor-sympathetic circuits (Kerman, 2008). Yoga postures share many of the physical and psychological benefits of exercise, in addition to specific features not shared by regular exercise. Yoga postures emphasize isometric muscular contractions while maintaining a specified anatomical alignment. Postures are generally performed in coordination with breath and are held steady and comfortably for a substantial length of time (Feuerstein, 1998; Sturgess, 1997).

Some authors have made very broad claims for the benefits of yoga, reporting that yoga postures are effective for improving one's neural, sensory, autonomic, and endocrinal functions (Kaliappan & Kaliappan, 1992). When practiced properly, postures improve balance, flexibility, range of motion, and attention to body alignment (DiBenedetto et al., 2005; Greendale et al., 2002). Specific yoga postures have shown to increase the flexibility of the shoulders and rib cage (Tran, Holly, Lashbrook, & Amsterdam, 2001). It has been proposed that maintaining (holding) postures lead to strengthening and relaxation of voluntary muscles which contributes to influence on the autonomic nervous system (Telles et al., 2004). Nayak & Shankara (2004) link yoga postures to diaphragmatic or full abdominal breathing. Specifically, the authors propose that the practice of postures develops muscle strength and flexibility, which in turn facilitates diaphragmatic breathing. Diaphragmatic breathing is considered to be one of the optimal breathing patterns for a person's overall health and stress/anxiety reduction (Novotny& Kravitz, 2007). Changes in the autonomic nervous system functioning have been also attributed to monitoring breath during yoga (Evans et al., 2009).

Based on the functioning of the sympathetic nervous system and hypothalamic-pituitary-adrenal (HPA) axis, Ross and Thomas (2010) attempted to explain why effects of yoga postures on a person's physical and psychological health differ from effects of regular exercise. Normally, the glucocorticoid response to an acute challenge and intense physical activity is enhanced in order to prepare the body for the most effective response to a stressor. Regular, intense exercise has a tendency to stimulate the sympathetic nervous system which results in increased levels of stress-related hormones cortisol, epinephrine and norepinephrene (Gatti & DePalo, 2010; Pedersen & Hoffman-Goetz, 2000; Ross & Thomas, 2010). In comparison, slow and mostly non strenuous yogic activities, including yogic postures have been associated with lowered sympathetic nervous system activation and decreased levels of the stress-related hormones (Banasik et al., 2011; Kamei et al., 2000, West et al., 2004).

West et al. (2004), for example, investigated effects of *Hatha* yoga on perceived stress and salivary cortisol. Sixty nine college students were assigned to one of the three groups: Hatha yoga, African dance, or a biology lecture as a control. The Perceived

Stress Scale (PSS) and salivary cortisol kit were used before and after one 90 minute session. Hatha yoga significantly decreased perceived stress along with African dance compared to the control group. In addition, mean levels of salivary cortisol, an indicator of activation of the HPA axis response to stress, decreased in Hatha yoga, increased in African dance, and had no change in the biology class (West et al., 2004).The authors hypothesized that the observed results may be due to differences in physiological arousal. A fundamental component of African dance is very intense aerobic activity while a fundamental component of yoga is isometric resistance training and stretching.

Streeter et al. (2010) designed a study in order to investigate effects of yoga versus walking on various health outcomes, including anxiety and GABA levels. Previous research suggests that low levels of GABA are associated with depression and anxiety disorders (Barbee, 1998). Thirty four healthy participants between 18 and 45 years old were randomly assigned to a 12-week intervention (3 times per week) of either yoga or walking. A maximum of 36 sessions could have been completed and each session lasted 60 minutes. The State Trait Anxiety Inventory (STAI) and Exercise-Induced Feeling Inventory were used as they are considered reliable and valid anxiety scales. Anxiety measurements were completed four separate times: pre-first session, and post-last session at weeks 4, 8, and 12. GABA levels were measured at pre and post session by using magnetic resonance spectroscopic imaging and assessments were done three times: pre-first session (Scan 1), post-12-week intervention (Scan 2), and post-60 minutes intervention that immediately followed Scan 2. A near-significant increase in acute GABA levels was found in the yoga intervention compared to the walking exercise and statistically greater decrease in anxiety levels was found in the yoga intervention compared to the walking intervention. That is an important finding, considering that walking was a condition metabolically matched to yoga. Thus, the authors suggested that the observed results were not due to the metabolic activity only. The well designed study did suffer from a high attrition rate (from 52 to 34). Although attrition was even in both groups (from 28 to 19 in yoga; from 24 to 15 in walking) the overall high attrition rate could potentially be a threat to internal validity.

Previous research demonstrates that yoga-based interventions are associated with decreased anxiety, decreased sympathetic nervous system and enhanced parasympathetic nervous system activity (Raghuraj & Telles, 2008; Smith et al., 2007; Streeter et al., 2007, 2010; West et al., 2004), and, therefore, can be beneficial for health conditions such as headache, where stress and anxiety are contributing factors (Wahben et al., 2008).

Yoga-Based Interventions and Headache Pain.

Although popularity of yoga as a CAM treatment for chronic pain conditions increases, there have been a limited number of studies investigating effects of yoga-based interventions on headaches. Kaliappan & Kaliappan (1992) recruited 20 patients suffering from migraine and tension headaches and randomized them into yoga therapy (postures and YB) group or no therapy (treatment as usual) control group. After 32 sessions over four months (twice per week), the yoga therapy group reported reductions in the headache activity (e.g. intensity, duration, and frequency) measured by self-reported rating scale, and medication intake. In comparison, the control group reported an increase in symptoms (Kaliappan & Kaliappan, 1992).

Bhatia et al. (2007) investigated the effect of NSAI drug, Botox A injection (10-12 equal doses), and yoga (YB, postures, meditation/relaxation) on temporalis muscle spasm in 15 patients with chronic tension-type headache. This specific muscle has been identified as a major contributor to tension-type headache, and possibly to migraine pain. Electromyography (EMG) was used to record the activity of the temporalis muscle during rest, mental activity, and maximal voluntary contraction. The visual analogue scale was used to measure pain. Even though an overactivity of temporalis muscle at rest and during mental activity and subjective pain scores decreased in all tested interventions, the authors reported a more significant decrease after the yoga-based intervention (Bhatia et al., 2007).

In a larger study of migraine sufferers, 72 patients were randomly assigned to either yoga therapy which included yoga postures, YB, and kriya (a nasal water cleansing process) or a self-care group for three months, and were assessed on primary outcomes (i.e. headache frequency, pain component) measured using the short form of the McGill Pain Questionnaire, and secondary outcomes (i.e. anxiety and depression) measured by the Hospital Anxiety Depression Scale. The yoga therapy group demonstrated lower headache frequency and lower pain rating compared to the self-care group. Furthermore, anxiety and depression scores were significantly lower in the yoga group (John et al., 2007).

Effect of Yoga on Pain: Mechanisms

While the mechanisms for reported effects of yoga on pain in general and headaches specifically are unclear, a number of plausible mechanisms have been proposed. Physical movement accompanied by enhanced body awareness that contribute to reduction of maladaptive postures, which might contribute to tension and pain, is one such mechanism (Sherman et al., 2010). It has been also proposed that pain perception can be altered by some physiological changes produced by yoga, including decreased sympathetic tone (e.g. reduced HR), reduction in inflammatory markers (e.g. Interleukin-6), and stress markers (e.g. cortisol) (Kielcolt-Glaser et al., 2010; Wren et al., 2011).

Potential causes of migraine include low blood supply to *meninges* and improper functioning of certain areas of the brainstem (e.g. respiration) (Lipton et al., 2007). Previous research also shows that headaches are often associated with stress and anxiety (Curry & Green, 2006; Dodick et al., 2003; Powers et al., 2006). It has been well established that stress and anxiety are accompanied by increased BP and HR. The product of HR and systolic blood pressure (SBP) is known as a rate pressure product (RPP), which allows calculation of the internal workload. RPP is a direct indication of the energy demand of the heart and, therefore, a good measure of the energy consumption of the heart and its efficiency. Thus, under increased stress/anxiety, the heart has to work harder in order to sufficiently supply blood, oxygen, and nutrients to all anatomical parts and organs, including head and brain. Yoga-based interventions have been associated with decreased BP (especially SBP) and HR (Kiecolt-Glaser, 2010; Raghuraj & Telles, 2008; Subbalakshmi et al., 2005). By decreasing both of these cardio-vascular variables, yoga-based interventions potentially allow the heart to work more efficiently thus contributing to a more efficient blood supply to the brain and lowered sympathetic nervous system activity. As a result, headache symptoms might lessen. Furthermore, yoga may reduce the sympathetic hyperactivity associated with pathogenesis of the pain condition (Da Silva et al., 2007).

Yoga may also contribute to some behavioral changes that positively affect headaches. These may include an increased social network or an increase in regular physical activity which can be performed at home. Psychological changes such as increased positive emotions, can also contribute to more efficient coping mechanisms and increased pain acceptance/tolerance and suffering (Jensen, 2011; Wren, Wright, Carson, & Keefe, 2011).

Considering that stress/anxiety reduction is important for prevention of health-related issues and management of existing chronic conditions (e.g. headache), investigation of all available approaches, including yoga, are warranted. While yoga does not necessarily reduce the level of pain, including headaches, it does appear to help with the management of stress/anxiety, pain and functionality (Carson et al., 2010; Sherman et al., 2005; Tilbrook et al., 2011). Despite increased interest in effects of yoga on various health outcomes, there is little in the published research literature that investigates effects of yoga on headache, or that compares the effects of yoga-based intervention versus physical activity on stress, anxiety, and headaches.

The Dissertation Project

The aim of this study was to investigate (1) whether YB can reduce the headache frequency, severity, medication intake and negative physiological and perceived effects of stress, and anxiety symptoms and (2) whether yoga postures can reduce the headache frequency, severity, medication intake and negative physiological and perceived effects of stress, and anxiety symptoms relative to a physical activity (walking) comparison group as well as a wait list control. The interventions took place over four weeks.

The average number of total headaches and average level of severity (last four weeks) was assessed by the numerical scales (0-10) at baseline and post-intervention. The *Headache Daily Diary* (John et al., 2007; Kappius & Goolkasian, 1987), that includes frequency and severity numerical scales, was used to monitor headaches on day-to-day basis. Medication intake was measured by brief questionnaire at a baseline and daily "Medication Intake Form". The *Henry Ford Headache Disability Index* (HDI) (Jacobson, Ramadan, Aggarwal, & Newman, 1994) was used to identify difficulties associated with headaches. Stress was measured by the *Perceived Stress Survey* (PSS) (Cohen, Kamarck, & Mermelstein, 1983), blood pressure (BP), and heart rate (HR). Anxiety was measured by the *State Anxiety Inventory* (SAI) (Spielberg, 1983), and depressive symptoms were measured by the CES-D (Radloff, 1977).

CHAPTER 2: METHODS AND MATERIALS

Overview and Design.

This study used an experimental design in which condition was an independent variable with four levels: yoga postures, yogic breathing (YB), physical activity (walking), and wait-listed. Frequency of headaches, severity of headaches, medication intake, HDI score, SAI score, CES-D score, PSS level, BP, and HR are the dependent variables. The design is a mixed model analysis of variance design where the between subjects factor is condition and the within subjects factors are DVs taken at baseline/4th week after last session.

The study included four groups (3 interventions; 1 control) and consisted of a 4 week intervention that was used for 20 minutes/day 5 times a week: 2 times in a group setting on the UNCC campus (on-site) and 3 times at home via use of Moodle (for web based video and data collection). Participants were randomly assigned to YB, yoga postures, walking, and wait-list control conditions in permuted blocks by using a random number generator. The Postures intervention consisted of yoga postures/asanas based on classical yoga practice and previous studies; the YB intervention used alternate nostril YB with retention, also known as *anuloma viloma;* the Physical Activity intervention was non-yoga-based and consisted of walking. Participants in the control group were administered all of the same measures but were on a wait-list during the 4 week period. Baseline measures were taken on Day 1 before the 1st session and at week 4 after the last session. All at-home measurements (e.g. frequency and severity of headaches, medication intake) were completed by participants electronically on Moodle study website.

Participants

Fifty eight University of North Carolina at Charlotte (UNCC) students were enrolled for the study through the General Psychology sign-up webpage (SONA systems) and UNCC e-mail as a result of posting information about the study on SONA, distributing posters describing the project to academic buildings, and distributing flyers to undergraduate students during regular psychology class periods. Randomization into groups occurred when participants arrived for their first session, after signing an informed consent. Seventeen students were assigned to the yoga postures (YP) group. Three of these participants did not complete required minimum number of on-site sessions (6 out of 8). Sixteen students were randomly assigned to the yogic breathing (YB) group. Two of these participants also did not complete four weeks of intervention. Seven students were assigned to the physical activity/walking (W) group and they all completed the study. Eighteen students were randomly assigned to the wait-listed (WL) control group and, of those, three participants did not follow the protocol and were dropped. Data from the eight students who did not complete the study were not included. The mean age was 20.72 years of age. Sixty-four percent of the participants were White, 21% were African-American, 4% were Asian, and 10% were biracial and Hispanic. Table 1 compares the participants in each of the two groups on demographic variables and all of the baseline measures collected in the study.

Conditions

In all three intervention groups (Yoga Postures, Yogic Breathing, and Physical Activity), participants were required to turn cell phones off at the start.

Yoga Postures Experimental Condition

The participants in the Yoga Postures group were asked to perform series of gentle yoga postures/ asanas for relieving headaches, stress, and anxiety. Neither YB nor guided breathing were a part of Yoga Postures sessions. Sessions were led by a yoga teacher with 200-hour Certification from the Kripalu School of Yoga and 10 years of experience in asanas and YB. The Kripalu School of yoga is licensed as a private occupational school by the Massachusetts Department of education and is a yoga Alliance-registered school (www.Kripalu/yogaschool.com). The instructor demonstrated and explained each posture to the participants before they started. After the initial instructions, the participants practiced performing each posture with an instructor's assistance. Participants then repeated postures in a pre-set sequence for 20 minutes. Supporting materials (print outs with sequence and directions for each posture) were given to all participants before they left. At-home sessions involved using video on the study's Moodle webpage with the same instructor and the same sequence of postures. Each participant had to manually sign-in on Moodle for each session.

YB Anuloma-Viloma Experimental Condition

YB sessions were led by the same yoga teacher as the Yoga Postures group. In session one, participants were asked to sit in a comfortable position either on a yoga pillow or on a chair with back, with their backs and necks vertically aligned. The full abdominal breath as the basis of *anuloma-viloma* was demonstrated and practiced for 3-5 minutes. It was determined that each participant was able to hold their breath for 12-15 seconds. Then the instructor demonstrated the *anuloma viloma* technique to the participants. After the initial instructions and 5 minutes of practice, the participants closed their eyes and performed *anuloma viloma* for 20 minutes following the standardized instructions . An audio recording of directions (e.g., nostril used for inhale and exhale) guided with a metronome ensured standardization in following the ratio. Proper technique was monitored throughout each session by the instructor by observing the motions of the abdomen, shoulders, and chest, and students were gently corrected when necessary. The subsequent on-site sessions followed the same protocol except the initial introduction. At-home sessions involved using video on the study's Moodle webpage with the same instructor and the same audio recording of directions guided with a metronome. Each participant had to manually sign-in on Moodle for each session.

Physical Activity Condition

The Physical Activity group engaged in walking at 2.5 mph for 20 minutes around the University campus. Based on a previous study (Streeter et al., 2010), this speed is metabolically matched to the yoga postures, and, therefore, was an appropriate active comparison to yoga. This activity was led by an RA. Participants were provided with print-outs of walking activity homework and pedometers. At-home sessions involved the same activity of walking for 20 minutes.

Control Condition

The control group was wait-listed for one of the interventions (yoga postures, YB, or walking). In addition to entering a drawing to win a $25 Target gift card, participants were also offered to attend 4 free 1 hour yoga classes (YB, asanas with guided breathing, relaxation) with certified yoga instructor upon completion of the experiment.

Materials

Self-Report Measures: General Information

We administered the Prescreen Questionnaire, the Expectancy Questionnaire, Demographic form, and the Short Form Health Survey (SF-36) on session 1 before the interventions. The SF-36 was also administered on session 20 after the interventions/last session.

1. Prescreen Questionnaire was used to assess student's eligibility requirement for the study.The prescreen questionnaire included questions about age, frequency of headache (at least 2 times a week for the last 30 days), ability to get on the ground/get up, pregnancy (women), recent (within 1 month) or chronic hip, knee/ankle, leg, shoulder, arm, wrist, eyes, ears, and back injury, symptoms of cold, respiratory infection or flu, and practicing postures and/or yogic breath control on a regular basis (1-2 times a week) for the last 30 days.
2. Expectancy Questionnaire was used to assess participants' expectations of yoga and physical activity (walking). Participants in all groups were asked the following questions: (1) ‘‘How effective do you consider yoga/walking for your overall health?’’ with answer options on a 4-point scale (0=not effective; 3= very effective) and (2) ‘‘What do you personally expect from the yoga techniques/walking that you will learn/do?" with answer options on a 4-point scale (0=no improvement; 3= cure). Similar measurements have been

used in previous Complementary and Alternative Medicine (CAM) studies (Linde et al., 2007), as it is important to assess the effects of expectancy in any CAM/Physical activity intervention.

3. Demographic Form was used to acquire sociodemographic data. This form was also used to identify participants who met exclusion criteria. Variables included age, gender, ethnicity, level of physical activity/exercises, and previous experience with yogic postures and yogic breathing.
4. SF-36 (Ware & Sherbourne, 1992) was used to assess participant's physical and mental health. The SF-36 consists of 36 questions which represent eight scales: physical functioning, role limitation due to physical health problems, bodily pain, general health, vitality, social functioning, role limitation due to emotional problems, and mental health well-being. The responses to questions for each SF scale are summed to provide 8 scores, which are then transformed into one multi-item scale that ranged from 0 (poorer health) to 100 (good health). High validity and reliability (alpha coefficient over 0.80) for each of the scales has been previously reported (McHorney et al., 1994; Ware et al., 1993), including among student population (Paro et al., 2010).

Self-Report Measures: Depression, Stress, and Anxiety Measures

We administered the Center for Epidemiological Studies of Depression Scale (CES-D), the Perceived Stress Survey (PSS), and the State Anxiety Inventory (SAI) on session 1 before the interventions and on session 20 after the interventions.

1. CES-D (Radloff, 1977) is well-validated and was used to assess depressive symptomology during the past week. Responses to the 20-item such as "I felt

sad" or "I didn't feel like eating; my appetite was poor" are based on five point Likert scale (0 = rarely or none of the time; 4 = most or all of the time). Possible range of scores is 0 to 60, with the higher scores indicating the presence of more depressive symptoms. (Radloff, 1977).

2. PSS (Cohen et al., 1983) was used to assess the degree to which an individual perceives his or her current stress. The 10 items on this scale ask about feelings and thoughts during the last 30 days. Items include questions such as "How often have you felt nervous and "stressed?", "How often have you found that you could not cope with all the things you had to do?" on a five-point scale (0=never; 4=almost always). PSS internal consistency, test-retest reliability, concurrent validity, and predictive validity have been tested in general population (Pau & Croucher, 2003). High internal reliability (alpha coefficient = .78) has been previously reported (Cohen & Williamson, 1988).
3. SAI is a 20- item scale designed to measure state anxiety (Spielberger, 1983). The SAI has been reported to exhibit high internal consistency with Cronbach's alpha of .73 (Spielberger, 1983). Statements like "I feel worried," are rated on a four-point scale from 1 (not at all) to 4 (very much so). Scores ranged from 20 to 80 with higher scores indicating more anxiety.

Self-Report Measures: Headache Measures

We administered the headache questionnaire (frequency and severity of headaches), the medication intake questionnaire, and the Headache Disability Inventory (HDI) on session 1 before the interventions and on session 20 after the interventions. Two of the items (headache frequency and headache severity) of the headache questionnaire were combined for a more robust headache score (Headache Rate). The Headache Daily Diary was completed by participants on a daily basis on the computer/online via Moodle.

1. Frequency was assessed by using a 6-point Numerical Scale (0=never; 5=every day). It rated the number of headache occurrences on average in last 4 weeks.
2. Severity was assessed by using a 10-point Numerical Scale (0=none; 10=severe) in response to a question: "How severe was your headache on average in last 4 weeks?"
3. Medication Intake was assessed by (1) asking the following two part question: "During last 30 days, how often have you taken a medication?"; "By using provided list, please choose medication used".
4. HDI (Jacobson et al., 1994) was used to identify difficulties associated with headaches. The 25-item questionnaire ask about difficulties that person may be experiencing because of headaches and include items such as "Because of my headaches I feel restricted in my daily activities", "I find it difficult to read because of my headaches" (0=no; 2= sometimes; 4=yes). Scoring of HDI scale includes emotional subscale, functional subscale, and total score with minimum score of 0 and maximum score of 100. The higher the score, the greater the disability caused by the headache.

Physiological Measures

Blood pressure (BP) and heart rate (HR) were measured with an FDA approved digital device (Omron HEM-780 Automatic BP Monitor). Cuffs were placed around bicep of non-dominant arm. Measures were taken over three consecutive cycles, and then averaged. Each reading took approximately 30-45 seconds. For all groups, the BP and HR measures were taken before the first session to establish the baseline, after the first session and before and after the last intervention session (about 20 minutes). In the control wait-listed group, the last cardiovascular measurements were taken before and after completion of all self-report measurements (about 20 minutes).

CHAPTER 3: PROCEDURE

Participants were assigned to condition/groups when they arrived for the experiment. Participants were randomly assigned to YB, yoga postures, walking, and wait-list control conditions in permuted blocks by using a random number generator. A random number generator (www.random.org) determined which intervention was used on any given day/time of the week. The schedule of experimental protocol and interventions for four groups is presented in Figure 1.

Day1

Upon arrival, participants filled-out a Pre-screen Questionnaire for inclusion/exclusion criteria. Then an informed consent form was signed by all participants followed by Expectancy Questionnaire. BP and HR were taken next and then participants were randomized in permuted blocks (n=3-5) to YB intervention, Yoga Postures intervention, Physical Activity intervention or control group. A Demographic form and baseline measures of frequency, severity, medication intake, HDI, PSS, CES-D, and SAI were taken. Then groups began one of the interventions. Immediately after the session, BP and HR were re-administered. BP and HR were re-administered in the control group after baseline self-report measures and then the control group was sent home with directions for accessing Moodle and filling out Daily Headache Diary for next four weeks.

The Yoga Postures group was introduced to a sequence of asanas, demonstrated by the instructor. After the initial instructions, the participants practiced each posture with the instructor's assistance. Participants then repeated postures in a pre-set sequence for 20 minutes. After the session, participants were provided print-outs of the postures sequence, steps/description for homework. Participants were instructed to record any additional yoga-related activities (e.g. postures, YB, meditation) or physical activities (e.g. walking, biking).

The YB group was asked to sit in a comfortable position either on the yoga pillow or the chair. They took several abdominal "full breaths" followed by 20 minutes of guided *anuloma viloma*. After the session, participants were provided print-outs of YB steps/description for homework. Participants were instructed to record any additional yoga-related activities (e.g. postures, YB, meditation) or physical activities (e.g. walking, biking).

The Physical Activity group engaged in 20 minutes of walking around the pond on the university campus led by an RA. After the session, participants were provided with print-outs of walking activity homework. Participants were also instructed to record any additional physical activities (e.g. walking, biking) or yoga-related activities (e.g. postures, YB, meditation) that they engaged in.

The Control group was given basic directions asking them to make no changes in their everyday routine and record any new physical activities (e.g. walking, biking) or yoga-related activities (e.g. postures, YB, meditation).

Day 2-27

Experimental groups performed 20 minute sessions at home three times/week and met either for YB, Yoga Postures, or Physical Activity two times a week and followed the study procedure. Participants in YB and Yoga Postures conditions used video on study's Moodle webpage for homework. Each participant had to manually sign-in on Moodle for each session. For participants' convenience, the Mind and Health lab with access to Moodle was available for completing YB and Yoga Postures homework sessions.

Day 28

Groups met for their last session of either for YB, Yoga Postures, Physical Activity or Control in the lab. Physiological measures (BP, HR) were administered before the last session and all baseline measures, including frequency, severity, medication intake, HDI, BP, HR, PSS, CES-D, and SAI were re-administered immediately following the last session. In the control wait-listed group, the last cardiovascular measurements were taken after completion of all self-report measurements (about 20 minutes). Each participant was debriefed about purpose of the study.

Hypotheses

1. We hypothesized that YB and Yoga Postures, performed 5 times a week for 20 minutes over a period of 4 weeks, will decrease the headache frequency and severity, compared to the physical activity (walking) group and to the control group (wait-list).
2. We hypothesized that YB and Yoga Postures, performed 5 times a week for 20 minutes/day over a period of 4 weeks, will decrease depressive symptoms and the negative physiological and perceived effects of stress and anxiety compared to the physical activity (walking) group and to the control group (wait-list).
3. We were interested in examining if YB and Yoga Postures practice would reduce physiological measures (blood pressure and heart rate). We hypothesized that both yoga-based groups would reduce heart rate and blood pressure from

sessions 1 to 20, and that the physical activity (walking) group and the control group (wait-list) would not.

Statistical Analyses

Statistical Package for Social Sciences 16.0 was used to conduct all statistical analyses. In general, the analyses tested for the between group effect of intervention training and the within group effect of pre/post (session 1 vs. session 20) intervention training. Significant interaction and group terms were examined with simple effects tests to determine the source of the main effect and interaction. A multivariate analyses of variance (MANOVA) was used (with Pillai's criterion as the test statistic) on the subscale scores on the SF-36, the headache scores (HDI, headache rate), and the SAI, CES-D, and PSS scores. Follow-up univariate analyses were conducted when appropriate. Pearson correlations were performed to investigate associations between level of attitude/expectancy and health outcomes. A significance level of .05 was used for all statistical tests.

CHAPTER 4: RESULTS

Demographic information and baseline (session 1) scores for measured variables are presented for each group in Table 1 and Table 2. There were no group differences on demographic variables (age; gender; ethnicity), cardiovascular, headache-related, and negative affect variables.

Expectancy Questionnaire

Correlations: General Attitude

Pearson correlation revealed that magnitude of positive attitude toward yoga in general and headache-related outcomes were not significantly correlated. The association between the attitude and HDI produced weak but positive correlation, r (50) = .22, p=.147, as well as weak association between the general attitude and the headache rate, r (50) = .15, p =.309. The association between level of positive attitude toward yoga in general and negative affect measures was also weak and not significant: SAI, r (50) = .14, p = .345, PSS, r (50) = .14, p = .351, and CESD, r (50) = .11, p = .433.

Pearson correlation revealed that degree of positive attitude toward walking in general and headache-related outcomes were also not significantly correlated. The association between the attitude and HDI produced week negative correlation, r (50) = -.23, p=.116, as well as weak association between the general attitude and the headache rate, r (50) = .09, p =.509. The association between level of positive attitude toward walking in general and negative affect measures was also weak and not significant: SAI, *r* (50) = -.13, *p* = .371, PSS, *r* (50) = -.09, *p* = .493, and CESD, *r* (50) = -.08, *p* = .581. Correlations are weak but in expected directions.

Correlations: Personal Expectations

There was no significant association between magnitude of expectations from learning the yoga techniques pertaining to headaches and headache-related variables. The association between the expectations and HDI produced very week correlation, *r* (50) = .09, *p* =.520, as well as even weaker association between the personal expectations and the headache rate, *r* (50) = .03, *p* =.826. The association between level of expectations of improvement with headaches from the walking 5 times a week for four weeks was also weak: HDI, *r* (50) = -.05, *p* = .711, and the headache rate, *r* (50) = .15, *p* = .288.

Headache Measures

Two of the items (headache frequency and headache severity) of a headache questionnaire were combined for a more robust headache measure (Headache Rate). Prior to conducting the MANOVA, Pearson correlations between Headache Rate and HDI were performed. Most of the dependent variables correlated with each other in a moderate range, thus supporting the appropriateness of MANOVA for examining the headache measures. The multivariate analysis conducted on the HDI and Headache Rate as a canonical dependent variable, demonstrated a main effect for session (Pre session 1/Post session 20), $F(2,45)=25.77$, $p<.001$; Pillai's Trace = .85, partial $\eta^2=.53$. There were marginally significant main effect of the group (yoga postures, YB, walking, wait-listed control), $F(6,92)=2.01$, $p=.072$; Pillai's Trace = .23, partial $\eta^2=.12$., and marginally significant interaction between group and session, $F(6,92)=1.89$, $p=.09$; Pillai's Trace =

.22, partial η^2=.11. Given the marginal significance of the overall test, follow up univariate analyses of each individual dependent variable were performed.

Headache Disability Index (HDI)

An analysis compared all groups on the HDI and found a significant main effect of session $F(1,46)=17.87$, $p<.001$, partial η^2=.28, but no main effect of group, $F(3,46)=1.16$, $p=.336$, partial η^2=.07, and no interaction between session and group, $F(3,46)=1.91$, $p=.142$, partial η^2=.11. Figure 2 demonstrates that after four weeks, HDI scores dropped for all groups. Even though a decrease in HDI scores was observed in all groups, the three intervention groups demonstrated a steeper drop compared to wait-listed control (Fig. 2).

Headache Rate

As indicated in Figure 3, after four weeks the headache rate decreased in all four groups, $F(1,46)=35.53$, $p<.001$, η^2=.44, but there was no main effect of group, $F(3,46)=2.15$, $p=.107$, partial η^2=.12. There was a marginally significant group and session interaction, $F(3,46)=2.45$, $p=.076$, partial η^2=.14, and we might note that while scores on headache rate did not differ much between groups, the drop from session 1 (M=13.07, SD=6.35) to session 20 (M=10.87, SD=6.46) appears to be smallest in the wait-listed group (Fig.3).

Perceived Stress, Anxiety, and Depression Measures

Prior to conducting the multivariate analysis of variance (MANOVA), Pearson correlations between PSS, SAI, and CESD were performed in order to examine the appropriateness of the MANOVA. Most of the dependent variables correlated with each other in a moderate range, thus supporting the use of MANOVA (Howel, 2007; Meyer, Gamps, & Guarino, 2006). The multivariate analysis conducted on the PSS, SAI, and CESD as a combined dependent variable, demonstrated a significant group effect, $F(3,41)=2.94$, $p=.003$; Pillai's Trace = .51; partial $\eta^2=.17$, and a significant session effect $F(3,41)=5.88$, $p=.002$; Pillai's Trace = .30; partial $\eta^2=.30$. There was also an interaction between group and session, $F(9,129)=2.04$, $p=.04$; Pillai's Trace = .37; partial $\eta^2=.12$. Given the significance of the overall test, follow up univariate analyses for each dependent variable was performed in order to examine each main effect and interaction.

State Anxiety Inventory (SAI)

An analysis compared all groups on the SAI and found a significant main effect of session $F(1,46)=8.07$, $p=.007$, partial $\eta^2=.15$, a significant main effect of group, $F(1,46)=4.37$, $p=.009$, partial $\eta^2=.22$, and the interaction between group and session $F(3,46)=4.24$, $p=.004$, partial $\eta^2=.25$. Figure 4 demonstrates that after four weeks, anxiety dropped for the three intervention groups, but increased for the wait-listed control. In order to see whether differences were significant, simple main effects were examined by using paired samples t-tests. In the yoga postures group, decrease in anxiety from baseline (M=40.36, SD=13.21) to session 20 (M=28.21, SD=5.31) was significant, t (13) =3.99, p=.002. Participants in the YB group also decreased their anxiety from pre (M=34.64, SD=14.69) to post (M=28.79, SD=12.00) significantly, t (13) =2.40, p=.03. The change was not significant in either walking (p=.13) or wait-listed control (p=.29) groups (Table 3).

Perceived Stress Scale (PSS)

The univariate analysis examining the PSS, found marginally significant main effect of group, $F(3,46)=2.39$, $p=.081$, partial $\eta^2=.14$, and no interaction between session and group (*F*<1). There was a significant main effect of session, $F(1,43)=13.73$, $p<.001$, partial $\eta^2=.26$, as after 4 weeks perceived stress decreased in all groups (Fig. 5).

Center for Epidemiological Studies of Depression Scale (CES-D)

The analysis examining the CESD found a significant main effect for session, $F(1,43)=16.53$, $p<.001$, partial $\eta^2=.28$, power = .98 (Fig.6). There was marginally significant main effect of group, $F(3,43)=2.32$, $p=.089$, partial $\eta^2=.14$, and group did not interact with session (F<1).

Short Form Health Survey (SF-36)

Table 4 and Table 5 present group means and standard deviations for each subscale of SF-36 across sessions. The multivariate analysis conducted on the eight subscales of the SF-36 as a canonical dependent variable exhibited significant main effect for session, $F(8,39)=2.52$, $p=.026$; Pillai's Trace = .34; partial $\eta^2=.34$. There were no group effect, $F(24,123)=1.06$, $p=.396$, partial $\eta^2=.17$, and session did not interact with group, $F(24,123)=1.28$, $p=.19$, partial $\eta^2=.20$.

Physiological Measures

A series of separate ANOVAs was conducted to examine systolic BP, diastolic BP, and heart rate (HR).

Systolic Blood Pressure

The first analysis examined systolic BP between groups at baseline and after the last session. The analysis did not find a main effect either for session (*F*<1) or for group (*F*<1). Session also did not interact with group (*F*<1).

Diastolic Blood Pressure

ANOVA compared the four groups on diastolic BP (pre1/post20), and did not find a main effect for either a session (*F*<1) or a group (*F*<1), and session did not interact with group, $F(3,46)=1.72$, $p=.18$. Figure 7 illustrates that observed changes in DBP from baseline to post last session did go in a different directions for groups: it descriptively increased in YB and walking ($p>.05$), but descriptively decreased in the yoga postures and the control ($p>.05$) groups.

Heart Rate (HR)

The ANOVA analysis on heart rate from baseline to after the last session found no main effect for session (*F*<1), no effect for group, (*F*<1), and marginally significant interaction between session and group, $F(3,46)=2.31$, $p=0.09$. Figure 8 shows that participants in the yoga postures group decreased their HR after 4 weeks, while participants in YB, walking, and wait-listed control increased their HR.

Additional Analysis (3 Groups)

Considering that (1) we had number of marginally significant main and interaction effects, (2) four groups did not have equal number of participants, and (3) the significance of a main effect or interaction is substantially influenced by the sample size, additional statistical analysis was performed with three groups only: the yoga postures (N = 14), the YB (N = 14), and the wait-listed control (N = 15). A multivariate analyses of variance (MANOVA) was used (with Willki Lambda criterion as the test statistic) on the headache scores (HDI, headache rate), the SAI, CES-D, and PSS scores, and the subscale scores on the SF-36. Follow-up univariate analyses were conducted when appropriate. A series of separate ANOVAs was conducted to examine systolic BP, diastolic BP, and heart rate (HR).A significance level of .05 was used for all statistical tests.

Headache Measures

The multivariate analysis conducted on the HDI and Headache Rate as a canonical dependent variable, demonstrated a main effect for session (Pre1/Post20), $F(2,39)=22.88$, $p<.001$; Wilks' Lambda = .76, partial $\eta^2=.54$. The power to detect an effect was 1.00. There were significant main effect of the group (yoga postures, YB, walking), $F(4,78)=2.49$, $p=.050$; Wilks' Lambda = .79, partial $\eta^2=.11$, and significant interaction between group and session, $F(4,80)=2.91$, $p=.027$; Wilks' Lambda = .76, partial $\eta^2=.13$. Given the significance of the overall test, follow up univariate analyses of each individual dependent variable were performed.

Headache Disability Index (HDI)

An analysis compared all groups on the HDI and found a significant main effect of session $F(1,40)=17.38$, $p<.001$, partial $\eta^2=.30$, but no main effect of group, $F(2,40)=1.24$, $p=.30$, partial $\eta^2=.06$. There was a marginally significant interaction between session and group, $F(2,40)=2.97$, $p=.063$, partial $\eta^2=.13$, and we might note that the largest drop from session 1 (*M*=43.29, *SD*=14.11) to session 20 (*M*=25.86, *SD*=12.88) was in the yoga postures group, followed by the YB group. The change from session 1 (*M*=42.27, *SD*=20.84) to session 20 (*M*=40.00, *SD*=22.05) appears to be smallest in the wait-listed group.

Headache Rate

There was no main effect of group, $F(2,40)=2.38$, $p=.106$, partial $\eta^2=.11$, but there was a significant session effect, $F(1,40)=29.09$, $p<.001$, $\eta^2=.42$, and a significant group and session interaction, $F(2,40)=3.37$, $p=.045$, partial $\eta^2=.14$. In order to see whether differences were significant, simple main effects were examined by using paired samples t-tests. In the yoga postures group, decrease in headache rate from baseline ($M=13.43$, $SD=6.48$) to session 20 ($M=4.43$, $SD=2.53$) was significant, t (13) =4.56, $p=.001$. Participants in the YB group also decreased their headache rate from pre ($M=16.57$, $SD=7.85$) to post ($M=10.14$, $SD=8.13$) significantly, t (13) =3.08, $p=.009$. The change was not significant in the wait-listed ($p=.19$) group.

Perceived Stress, Anxiety, and Depression Measures

The multivariate analysis conducted on the PSS, SAI, and CESD as a combined dependent variable, demonstrated a significant group effect, F (6,72)=3.33, $p=.005$; Wilks' Lambda = .61; partial $\eta^2=.22$, and a significant session effect $F(3,35)=5.87$, $p=.002$; Wilks' Lambda = .67; partial $\eta^2=.34$. There was also an interaction between group and session, F (6,72)=2.66, $p=.022$; Wilks' Lambda = .66; partial $\eta^2=.19$. Given the significance of the overall test, follow up univariate analyses for each dependent variable was performed in order to examine each main effect and interaction.

State Anxiety Inventory (SAI)

An analysis compared groups on the SAI and found a significant main effect of session $F(1,40)=7.09$, $p=.011$, partial $\eta^2=.15$, a significant main effect of group, $F(2,40)=5.84$, $p=.006$, partial $\eta^2=.23$, and the interaction between group and session $F(2,40)=7.04$, $p=.002$, partial $\eta^2=.26$. After four weeks, anxiety dropped for the two intervention groups, but increased for the wait-listed control (Table 3).

Perceived Stress Scale (PSS)

The univariate analysis examining the PSS, found no significant main effect of group, F (2,40) =1.62, p=.211, partial η^2=.08, and no interaction between session and group (F<1). There was a significant main effect of session, F (1,40)=12.53, p =.001, partial η^2=.24, power = .93, as after 4 weeks perceived stress decreased in all three groups.

Center for Epidemiological Studies of Depression Scale (CES-D)

The analysis examining the CESD found a significant main effect for session, F(1,37)=18.13, p<.001, partial η^2=.33.There was marginally significant main effect of group, F (2,37)=2.53, p=.093, partial η^2=.12, and group did not interact with session (F<1).

Short Form Health Survey (SF-36)

The multivariate analysis conducted on the eight subscales of the SF-36 as a canonical dependent variable exhibited a significant main effect for session, F(8,33)=2.78, p=.018; Wilks' Lambda = .60; partial η^2=.40 The power to detect effect was .87. There were no group effects, *(F<1)*, but session interacted with group, F(16, 66)=1.88, p=.039, partial η^2=.31. Given the significance of the overall test, follow up univariate analyses of each individual subscale were performed.

The analysis on the *physical functioning* subscale of the SF-36 found significant group effect, F (2,40)=3.70, p=.034, partial η^2=.16, and marginally significant main effect for session, F (1,40)=3.078, p=.087. The groups did not interact with session, F (2,40)=2.01, p=.147, partial η^2=.09. We compared all groups on the role limitations due to *physical health* subscale of the SF-36, and found significant session effect, F

(1,40)=7.74, p=.008, partial η^2=.16, and no group effect, F(2,40)=1.90, p=.16, partial η^2=.09. Session also didn't interact with group F (2,40)=1.18, p=.318 , partial η^2=.06.

The analysis on the *role limitations due to emotional problems* subscale of the SF-36, found no significant group effect (F <1). There was a significant main effect of session as all groups reduced limitations, F(1,40)= 11.86, p=.001, partial η^2=.23, but observed change in limitations due to emotional problems over time was not different for the groups, F (2,40)=2.36, p=.11, partial η^2=.11.

When comparing groups on the *energy/fatigue* subscale of the SF-36, we found that all groups increased energy/decreased fatigue from session 1 to 20, F(1,40)=9.16, p=.004, partial η^2=.19, and that the type of group had marginally significant effect on the energy/fatigue level, F (2,40)=2.68, p=.081, partial η^2=.12. The improved energy/decreased fatigue also did vary by group, F(2,40)=3.13, p=.05, partial η^2=.14 (Fig.9). Paired samples t-test examining the level of improvement within each group showed that in the yoga postures group improvement from baseline (M=43.07, SD=13.35) to session 20 (M=60.71, SD=15.17) was significant, t (13)=3.12, p=.008. The difference was not significant in YB (p=.124), and wait-listed (p=.884) groups.

Emotional well-being increased in all groups after 4 weeks, F (1,40)= 17.18, p<.001, partial η^2=.30, power =.98, and observed improvement across sessions was not different for YB, yoga posture, walking, and control groups (F<1). There was also no group effect, F (2,40)=2.13, p=.132, partial η^2=.10.

Social functioning improved in four groups significantly, F (1,40)=9.78, p=.003, partial η^2=.20. There was no group effect, F (2,40)=2.31, p=.113, partial η^2=.10, and no interaction between session and group, F (2,40)=1.89, p=.169, partial η^2=.09.

The analysis on the *pain* subscale of the SF-36, found no significant session effect ($F<1$), but the type of group had significant effect on changes in the pain level, $F(2,40)= 3.95$, $p=.027$, partial $\eta^2=.17$. Groups also interacted with session, $F(2,40)= 4.43$, $p=.018$, partial $\eta^2=.18$ (Fig.10). This scale used reverse scoring: higher score means less bodily pain and less interference of pain with normal work. Paired samples t-test examining the level of decrease in pain-related issues within each group, showed that participants in the yoga postures group decreased their bodily pain and its interference with normal work from session 1 ($M=72.86$, $SD=14.61$) to session 20 ($M=89.82$, $SD=7.10$) significantly, $t(13)=4.63$, $p<.001$. The difference was not significant in YB ($p=.952$) and wait-listed ($p=.355$) groups.

General health improved significantly in YB, YP, and control, $F(1,40)=8.01$, $p=.007$, partial $\eta^2=.17$, power = .79. There was no group effect ($F<1$), and no interaction between session and group ($F<1$).

Physiological Measures

A series of separate ANOVAs was conducted to examine systolic BP, diastolic BP, and heart rate (HR).

Systolic Blood Pressure

The first analysis examined systolic BP between groups at baseline and after the last session. The analysis did not find a main effect either for session ($F<1$) or for group ($F<1$). Session also did not interact with group ($F<1$).

Diastolic Blood Pressure

ANOVA compared the four groups on diastolic BP (pre1/post20), and did not find a main effect for either a session ($F<1$) or a group, $F(2,40)=1.27$, $p=.29$, $\eta^2=.06$, and session did not interact with group, *F* (2,40)=2.28, *p*=.115, η^2 =.10. As with 4 groups analysis, observed changes in diastolic BP from baseline to post last session did go in different directions for groups: it descriptively increased in YB (*p*>.05), but descriptively decreased in the yoga postures and the control (*p*>.05) groups.

Heart Rate (HR)

The ANOVA analysis on HR from baseline to after the last session found no main effect for session (*F*<1), no effect for group, (*F*<1), and marginally significant interaction between session and group, *F* (2,40)=2.82, *p*=0.071, η^2 =.12. Even though HR between different groups did not reach statistical significance, we might note that observed changes in HR went in a different direction for groups: only participants in the yoga postures group decreased their HR from session 1(*M*=79.61, *SD*=9.06) to session 20 (*M*=74.00, *SD*=8.84), while participants in YB slightly increased it from pre (*M*=76.14, *SD*=8.91) to post (*M*=78.10, *SD*=14.56). Participants in wait-listed control also experienced increase from pre (*M*=76.02, *SD*=11.79) to post (*M*=77.75, *SD*=13.05).

CHAPTER 5: DISCUSSION AND CONCLUSIONS

This randomized controlled trial evaluated the effectiveness of yoga-based interventions (yoga postures, yogic breathing) on headaches and negative physiological and perceived effects of stress, depressive and anxiety symptoms relative to a physical activity (walking) comparison group as well as a wait list control. Our findings with naïve participants learning and then practicing yoga postures and yogic breathing (YB), and participants practicing brisk walking, suggest that there are beneficial effects of both yoga-based activities as well as walking, on various headache-related parameters, (frequency, severity, headache-associated difficulties), and on perceived anxiety after 4 weeks (up to 5 days/week, 20 min/day) compared to a wait-listed control group. For the most part, observed results were in the direction of proposed hypotheses.

As hypothesized, the yoga postures demonstrated greater and consistent level of improvement on the following health measures: headache rate (frequency and severity of headaches), headache-associated difficulties measured by the Headache Disability Index (HDI), anxiety levels measured by SAI, and heart rate, although not all of them reached significance level. Compared to the wait-listed group, participants in the yoga postures group demonstrated steeper decrease in the HDI. While changes in headache symptoms occurred in all groups, the yoga posture group reported that headache rate decreased descriptively more than in wait-listed control. This observed benefit was even more evident when only three groups (yoga postures, YB, and control) were compared as the decrease in headache rate scores reached significance for the yoga postures group.

Practicing yoga postures for 20 minutes a day, up to 5 times a week for four weeks resulted in the largest significant drop in perceived anxiety, compared to walking for the same period of time. Participants in the wait-listed control group actually increased their level of anxiety after 4 weeks. Practicing yoga postures, however, did show any differential change in perceived stress and depressive symptoms as after four weeks perceived stress, and depressive symptoms decreased in all groups. Although changes in cardiovascular variables did not reach significance in any of the groups, practicing yoga postures resulted in slight decrease in diastolic BP and heart rate. Furthermore, the yoga postures group is the only group that reported decrease in heart rate after four weeks.

Additional benefits for overall physical and emotional health surfaced when only yoga-based interventions were compared to the wait-listed control. There was a significant decrease in bodily pain and interference of pain with normal work and also a significant increase in energy/decrease in fatigue after practicing yoga postures but not yogic breathing. The observed results could represent beneficial effects of yoga postures on headache and pain-related issues, perceived anxiety, some of the cardiovascular variables, and overall level of energy/fatigue.

The YB group also demonstrated greater and consistent levels of improvement on the following health measures: steeper decrease in both HDI scores and the headache rate compared to the control. Decrease in the headache rate reached significance when only yoga-based interventions were compared to the wait-listed control.

Similar to the yoga postures group, perceived anxiety decreased significantly across test sessions for the YB group. Compared to the yoga postures group, participants in the YB group actually descriptively increased their diastolic BP and heart rate after practicing yogic breathing for 20 minutes a day, up to 5 times a week for four weeks. The observed results could represent beneficial effects of YB on perceived anxiety and headache-related issues, but not on cardiovascular variables.

Walking for 20 minutes a day, up to 5 times a week for four weeks also appeared to be beneficial as participants in that group demonstrated steeper decrease in both HDI scores and headache rate compared to wait-listed controls. Although participants in the walking group decreased their perceived anxiety level after four weeks, this change did not reach significance compared to two other intervention groups (YB, yoga postures). Similar to the YB group, participants in the walking group increased (descriptively) their diastolic BP and HR. The observed results support the notion of physical activity being beneficial for headache-related issues and perceived anxiety.

Although the wait-listed control group demonstrated a decrease on all the headache measures, decline in HDI scores was not as steep as in the yoga postures, YB, and walking groups. Furthermore, change in a headache rate was the smallest out of all groups. Compared to three intervention groups, participants in the wait-listed group actually increased their level of perceived anxiety. Cardiovascular changes included the following: similar to the yoga postures group, diastolic BP slightly increased after 4 weeks for people on the wait-list; similar to the YB and walking groups, heart rate slightly increased. The observed results suggest that the beneficial effects on perceived anxiety, headache-related issues, and cardiovascular variables that was seen in the three intervention groups, and especially in the yoga postures and yogic breathing groups, was not evident in the control.

Even though yoga has been practiced for thousands of years, only recently have researchers started to demonstrate yoga's effect on various health variables, including pain (e.g. headaches), stress, and anxiety. Based on the existing literature, we had several reasons to expect that yoga-based interventions might reduce headache-related symptoms and improve negative affect.

First, it has been proposed that yoga postures and yogic breathing produce the relaxation response by shifting away from sympathetic (excitatory) dominance (Brown & Gerbarg, 2005; Carson et al., 2010; Novotny & Kravitz, 2007; Sovik, 2000). Nayak & Shankara (2004) link asanas to diaphragmatic or full abdominal breathing. Specifically, the authors propose that the practice of asanas develops muscle strength and flexibility, which in turn facilitates diaphragmatic breathing. Diaphragmatic breathing is considered to be one of the optimal breathing patterns for a person's overall health and stress/anxiety reduction (Novotny& Kravitz, 2007). Interestingly, in our study we did not coordinate yoga postures movement with breath, which is traditionally done in yoga practice. One of the reasons was to investigate if postures themselves would have a beneficial effect on headaches, cardiovascular variables, and negative affect (stress/anxiety, depressive symptoms). Despite of intentional lack of breath/movement coordination, participants in the yoga postures group reported positive effects on health outcomes. Previous research demonstrates that yoga-based interventions are associated with decreased anxiety, decreased sympathetic nervous system and enhanced parasympathetic nervous system activity (Streeter et al., 2007, 2010; West et al., 2004; Smith et al., 2007; Raghuraj &

Telles, 2008), and, therefore, can be beneficial for health conditions such as headache, where stress and anxiety are contributing factors (Wahben et al., 2008).

Second, yoga produces invigorating effects on mental and physical states, and thereby may improve levels of fatigue and energy associated with pain (Carson et al., 2010), possibly including headaches. The pilot study from our lab, investigating effects of short-term YB training on stress and cardiovascular variables, found that three consecutive sessions (20 minutes each) of the same *anuloma viloma* YB technique, resulted in decreased fatigue levels across test session for the YB group, but in increased levels for the control group (David et al., 2011).

Third, the reported benefits of regular yoga practice include muscular flexibility and strength that contributes to improved bone alignment and posture. Considering that tension, neck or back strain due to poor posture are among some of the most common causes of tension-type headache, improved posture can explain some of the observed benefits. Forth, yoga cultivates a healthy acceptance of and willingness to learn from pain and other stressful experience (Carson et al., 2010).

Recent reviews of exercise trials concur that physical exercise in general and/or increase in physical activity improves some pain-related issues, including headaches (Sjogren, 2005). Thus, observed benefits of brisk walking also are not surprising. The question about additional observed benefits of yoga postures compared to the physical activity – walking in our case, remains. Yoga postures share many of the physical and psychological benefits of exercise, in addition to specific features not shared by regular exercise. Yoga postures emphasize isometric muscular contractions while maintaining a specified anatomical alignment. Improved proper alignment along with maintaining (holding) postures that lead to strengthening and relaxation of voluntary muscles (Bhatia et al., 2007; Telles et al., 2004) might be additional factors contributing to benefits observed in the yoga postures group, that were beyond benefits observed in the walking group. Furthermore, each of the yoga posture sessions ended with *shavasana* or *corpse* pose which is a deeply relaxing (lying on your back) pose. In comparison, no relaxation was done after each walking session. Thus, the increased diastolic BP and heart rate in the walking group can be explained by the normal physiological changes associated with any type of exercise, but especially with cardiovascular exercises.

The current study did not fully replicate previous cardiovascular findings associated with yogic breathing, such as decreased diastolic BP and decreased heart rate (Raghuraji & Telles, 2008; Sabbalakshmi et al., 2005). There are a few possible explanation for opposite trends in the cardiovascular results in our study. Physical activity is known to increase both cardiovascular markers (BP and HR). Thus, observed increase in diastolic BP and HR in the walking group was not surprising. YB has an element of physical exertion as movements of breathing have to be controlled and maximized in order to follow the specified inhalation/exhalation ratio. Furthermore, previous studies found that strained breathing and inspiratory breath holding contributes to increased BP (Fokkema, 1999). Participants with no prior experience could have found the breath holding in our protocol somewhat strenuous. Although practicing YB for 20 minutes 5 times a week for 4 weeks was expected to acquire some adaptation to *anuloma viloma*, and participants claimed that they practiced YB at home according to the protocol, only eight on-site sessions can be verified. Therefore, reductions in HR and BP for the YB participants may have been blunted by the exertion of the YB technique with breath holding that did not decrease due to not following recommended protocol. A significant decrease in these two variables has been found when YB without retention and experienced practitioners were used. Furthermore, our participants were recruited from a young population with overall healthy levels of BP and HR (despite the headache issues). Large decreases on cardiovascular variables cannot be expected in young, healthy populations.

One of the major concerns with any CAM or exercise research is the role of patient expectations, which may confound the results with a bias toward positive outcomes (Linde et al., 2007). Linde and colleagues (2007), for example, found a significant association between better improvement and higher outcome expectations in their analyses of four randomized controlled trials of acupuncture in patients with various pain conditions, including tension-type headache and migraine. Based on our analysis, the magnitude of positive attitude toward yoga in general and higher headache-related outcomes were not significantly correlated.

Headache rate decreased in all three intervention groups after four weeks with the yoga postures group demonstrating steeper decrease. Anxiety also decreased significantly in both yoga-based intervention groups but not in the walking or wait-listed control group. Additional benefits for headache symptoms surfaced when only yoga-based interventions were compared to the control. There was a significant decrease in a headache rate for both postures and YB. Previous research shows that in principle, expectations can positively affect an outcome (Linde et al., 2007) by possibly modifying pain perception in the brain (Wager et al., 2004). In our study, expectations were high for all groups, nonetheless the yoga-based groups had better outcomes on headache-related variables and anxiety. Thus, when controlling for personal expectations, expectations likely contributed to some extent to the observed improvements, but they do not explain the outcomes.

There are several limitations to this study. Yoga is a discipline which is divided into many schools that vary in their emphasis, techniques, and, therefore, individual practices (Feuerstein, 2001). Dozens of classically identified existing yoga postures can be practiced in various ways. In this study we developed a protocol/routine that included only some of the simple postures which tend to relieve headaches and stress/anxiety and they were practiced with holding time of 30-35 seconds each. Thus, it is unclear from this study whether a different yoga regimen would have yielded similar or different results or benefits.

Even though at-home sessions for both yoga postures and yogic breathing involved using video on the study's Moodle webpage with the same instructor and each participant had to manually sign-in on to Moodle for each session, some of the students communicated to the investigators that they downloaded the video to either their I-pods or their smart phones for convenience. Thus, monitoring adherence to homework was more challenging. There is a possibility that participants did not follow the protocol as it was designed. Based on the post-study Compliance questionnaire, at-home assignments were completed (on average) two times by the yoga postures participants, three times by the yogic breathing participants, and three times by walking group. The responses are self-reported and there is no way to verify provided responses.

It has been proposed that an increased social network and psychological changes such as increased positive emotions that come with increased social interactions, can also contribute to more efficient coping mechanisms and increased pain acceptance/tolerance and suffering (Jensen, 2011; Wren et al., 2011). Compared to the wait-listed group, three intervention groups received additional attention during on-site sessions, which potentially could influence the outcome. However, the three intervention groups received the same amount of additional attention during their on-site sessions, yet, yoga-based activities appeared to provide more health-related benefits.

Participants were not blinded to the assigned condition due to the inability to create a sham to mask any of the interventions used in the study. Therefore, there is a possibility that after being assigned to different conditions, participants in the intervention groups, and especially in yoga postures and the yogic breathing groups, may have been biased toward recording a favorable result after four weeks, while the control group alternatively may have wished to demonstrate an unfavorable outcome.

We also did not obtain long-term follow-up data which would allow us to comment upon the durability of the treatment effect. Finally, participants were a group of young college students, suggesting caution in generalizing the results to a broader population. There is a possibility that the perceived stress and depressive symptoms measurements were not sensitive enough for this overall healthy population. The generalizability of our preliminary findings is also restricted by the small sample size and reliance on self-reported data with the exception of the cardiovascular measures.

The current study improved on the methodology of prior yoga studies by employing two comparison groups: an active (physical activity/walking) comparison group, and passive (wait-listed) control group. In addition, the study used a Moodle account for (1) posting videos for yoga-based at-home sessions; (2) daily headache diaries, and (3) monitoring overall adherence to a study protocol. We also used a novel YB technique (*anuloma viloma*) to examine whether regular YB practice with breath holding can affect various health measures. Both yoga-based interventions were led by the same instructor, thereby minimizing the effect of different treatment of participants as a potential extraneous variable. To our knowledge, this is the first study to use the Expectancy Questionnaire as a way to investigate effect of attitude toward *yoga* and personal expectations from learning and practicing yoga techniques on health-related outcomes.

The study provides preliminary evidence that yoga-based interventions can be effective tools to assist in dealing with headaches, headache-related issues, and anxiety. The improvements documented in this randomized control trial are important enough to warrant future study.   Further methodological improvements could include large sample size, better assessment of "headaches" condition using medical records and documenting presence/occurrence of headaches using hand held devices, improved assessment of adherence to the protocol, and follow-up assessments. Considering the practice and philosophy behind classical yoga, combined effects of *regular* practice may be the most beneficial element of yoga intervention. Thus, employing an additional yoga-based group that involves breath/movement coordination may assist in investigating whether combining two elements of yoga will produce beneficial effects on headaches, stress and depressive symptomology.

Nonetheless, this study makes an important contribution to the literature by showing that yoga-based interventions can be beneficial to pain and headache-related issues, anxiety, and energy/fatigue levels. Observed benefits appear to go beyond just an increase in physical activity as practicing yoga postures demonstrated either stronger or additional positive effects on health outcomes compared to a physical activity in a form of brisk walking. The study also demonstrated that both simple yoga postures and YB techniques (e.g. *anuloma viloma*) are acceptable and can be effectively taught by an experienced practitioner to a naïve undergraduate sample. In conclusion, yoga is promising intervention as training and maintaining practice are low-cost, easily accessible by many (e.g. DVD, internet), and, if practiced correctly, presents a minimal risk of adverse effects to both healthy people and people with health conditions, including headaches. Furthermore, as the public is becoming increasingly interested in the use of CAM, the popularity of yoga as a CAM approach to health is likely to continue. Large scale randomized control trials with methodological improvements described above is recommended in order to draw definitive and firm conclusions about the use of yoga-based interventions for various health conditions and outcomes, including headaches, stress, and anxiety.

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APPENDIX A: TABLES

Table 1. Yoga-Based Group comparison on baseline scores for each of the measured variables

	Yoga Postures	*YB*	*F/ χ^{2*}*	*P*
Baseline Mean (SD)				
Age	19.86 (1.10)	22.29 (6.75)	16.02	.89
Caucasian	64.3	50.00	15.20	.44
Female	92.9	85.7	. 99	.80
S.B.P	105.73 (9.95)	106.78 (14.48)	.19	.91
D.B.P	70.81 (7.66)	71.99 (8.07)	.12	.95
H.R	79.62 (9.06)	76.14 (8.91)	.78	.50
HDI	43.29 (14.11)	38.71 ((18.66)	.35	.79
HEART RATE	13.43 (6.48)	16.57 (7.85)	.94	.43
SAI	40.36 (13.21)	34.64 (14.69)	1.13	.35
CESD	19.00 (6.30)	19.21 (17.04)	1.86	.15
PSS	21.64 (4.96)	19.14 (6.96)	1.15	.34

df=3,49. S.B.P *(Systolic Blood Pressure),* D.B.P *(Diastolic Blood Pressure),* H.R. *(Heart Rate),* SAI *(State Anxiety Inventory),* CESD (*Center for Epidemiologic Studies Depression Scale*), *PSS (Perceived Stress Survey).*

Table 2. Walking and Wait-List Group comparison on baseline scores for each of the measured variables

	Walking	*Wait-List*	F/χ^{2*}	*P*
Baseline Mean (SD)				
Age	20.29 (1.25)	20.27 (2.15)	16.02	.89
Caucasian	71.4	66.7	15.20	.44
Female	85.7	80.00	. 99	.80
S.B.P	105.80 (13.74)	103.29 (14.21)	.19	.91
D.B.P	72.85 (12.37)	70.99 (7.54)	.12	.95
H.R	81.71 (9.62)	76.02 (11.79)	.78	.50
HDI	36.00 (16.77)	42.27 (20.84)	.35	.79
HEART RATE	12.36 (5.79)	13.07 (6.35)	.94	.43
SAI	36.00 (9.75)	42.40 (10.32)	1.13	.35
CESD	14.86 (5.01)	26.58 (10.03)	1.86	.15
PSS	17.00 (6.43)	21.27 (6.43)	1.15	.34

df=3, 49. S.B.P *(Systolic Blood Pressure),* D.B.P *(Diastolic Blood Pressure),* H.R. *(Heart Rate),* SAI *(State Anxiety Inventory),* CESD (*Center for Epidemiologic Studies Depression Scale*), *PSS (Perceived Stress Survey).*

Table 3. Means and Standard Deviations for four groups on SAI.

	Pre (Before Session1)		*Post* (After Session 20)	
	M	*SD*	*M*	*SD*
Yoga Postures	40.36	13.20	28.21*	5.31
Yogic Breathing	34.64	14.69	28.79*	12.00
Walking	36.00	9.75	31.43	6.05
Wait-List	42.40	10.32	46.26	14.13

Note. * *denotes group significantly less anxiety scores than controls.*

Table 4. Means and Standard Deviations for Yoga-Based Groups on SF-36 subscales.

	Yoga Postures				*YB*			
	Pre[a]		*Post*[a]		*Pre*[b]		*Post*[b]	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Physical Functioning	90.00	10.56	96.43	4.97	94.29	12.54	91.79	13.24
Physical Health	55.36	39.44	92.86	20.64	67.86	39.75	87.50	23.51
Emotional Problems	45.24	46.42	66.67	41.35	37.14	43.34	85.72	28.39
Energy/Fatigue	43.07	13.35	60.71	15.17	51.43	21.16	58.57	15.98
Well-Being	76.00	8.88	66.00	15.03	73.71	19.00	59.43	25.92
Social Functioning	67.32	24.78	86.61	15.86	75.89	27.94	83.75	22.68
Pain	72.86	14.61	89.82	7.10	77.32	26.72	76.96	26.09
General Health	63.93	13.18	70.36	13.22	65.00	22.10	72.86	13.83

Note. [a]n= 14 , [b]n= 14.

Table 5. Means and Standard Deviations for Walking and Wait-List Groups on SF-36 subscales.

	Walking				*Wait-List*			
	Pre[a]		*Post*[a]		*Pre*[b]		*Post*[b]	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Physical Functioning	92.14	7.56	93.57	5.56	78.33	22.96	87.33	14.38
Physical Health	78.57	30.37	88.09	20.89	56.67	42.75	65.00	39.87
Emotional Problems	80.95	37.80	85.71	26.23	42.22	42.66	51.11	46.92
Energy/Fatigue	55.00	16.33	60.71	18.35	42.33	19.17	43.00	19.07
Well-Being	82.57	3.78	76.57	8.77	61.33	19.98	53.73	24.64
Social Functioning	87.50	12.50	89.29	11.25	63.33	18.58	67.50	21.02
Pain	82.86	20.94	82.86	10.94	66.50	23.37	59.50	24.02
General Health	60.71	17.90	60.00	15.00	61.67	17.08	64.33	17.51

Note.[a]n=7 , [b]n= 15 .

APPENDIX B: FIGURES

Session 1	Session 2-19	Session 20
Before BP HR HDI Frequency Severity Medication Intake SF-36 PSS SAI CESD Intervention YB Yoga Postures Walking Waiting 20 min. After BP HR	On-Site Intervention (2 times/week) YB Yoga Postures Walking At-Home Intervention (3 times/week) YB Yoga Postures Walking No intervention Wait-Listed	Before BP HR Intervention YB Yoga Postures Walking Waiting 20 min. After BP HR HDI Frequency Severity Medication Intake SF-36 PSS SAI CESD

Figure 1. Schedule of experimental protocol and interventions for four groups.

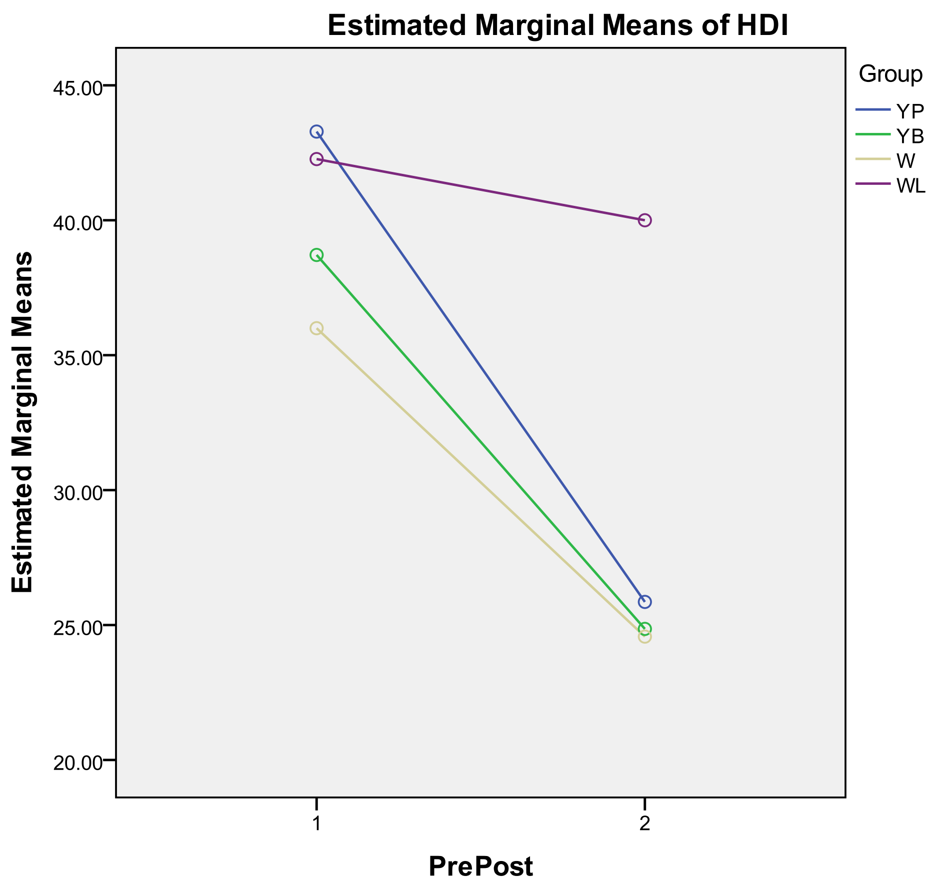

Figure 2. Mean scores on the HDI for the YB (*n*= 14), yoga postures (*n*=14), walking (*n*=7), and wait-listed control (*n*= 15) groups on baseline and post-intervention measurements.

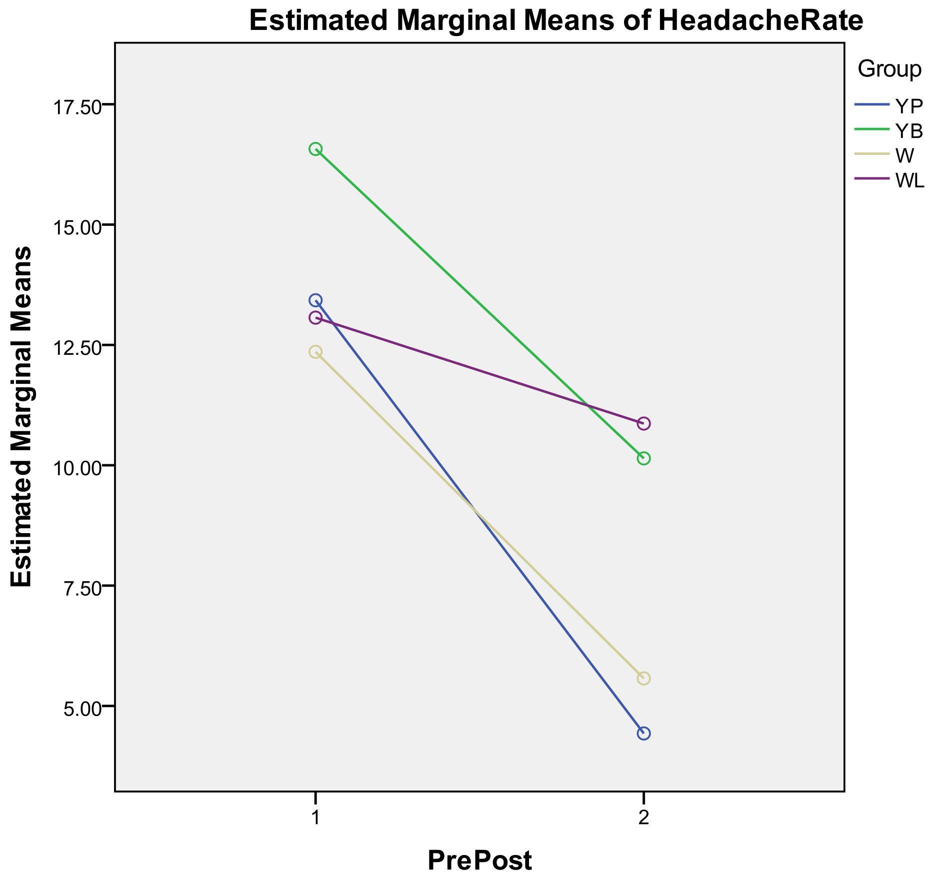

Figure 3. Mean scores on the Headache Rate for the YB (*n*= 14), yoga postures (*n*=14), walking (*n*=7), and wait-listed control (*n*= 15) groups on baseline and post-intervention measurements.

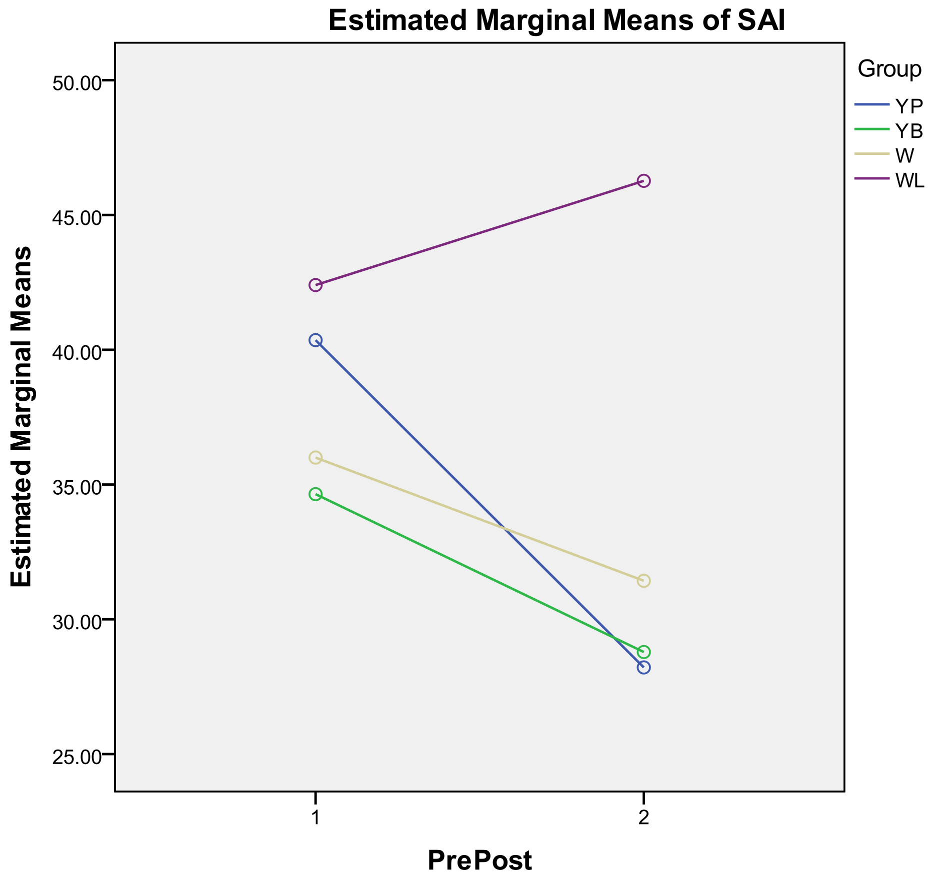

Figure 4. Mean scores on the SAI for the YB (*n*= 14), yoga postures (*n*=14), walking (*n*=7), and wait-listed control (*n*= 15) groups on baseline and post-intervention measurements.

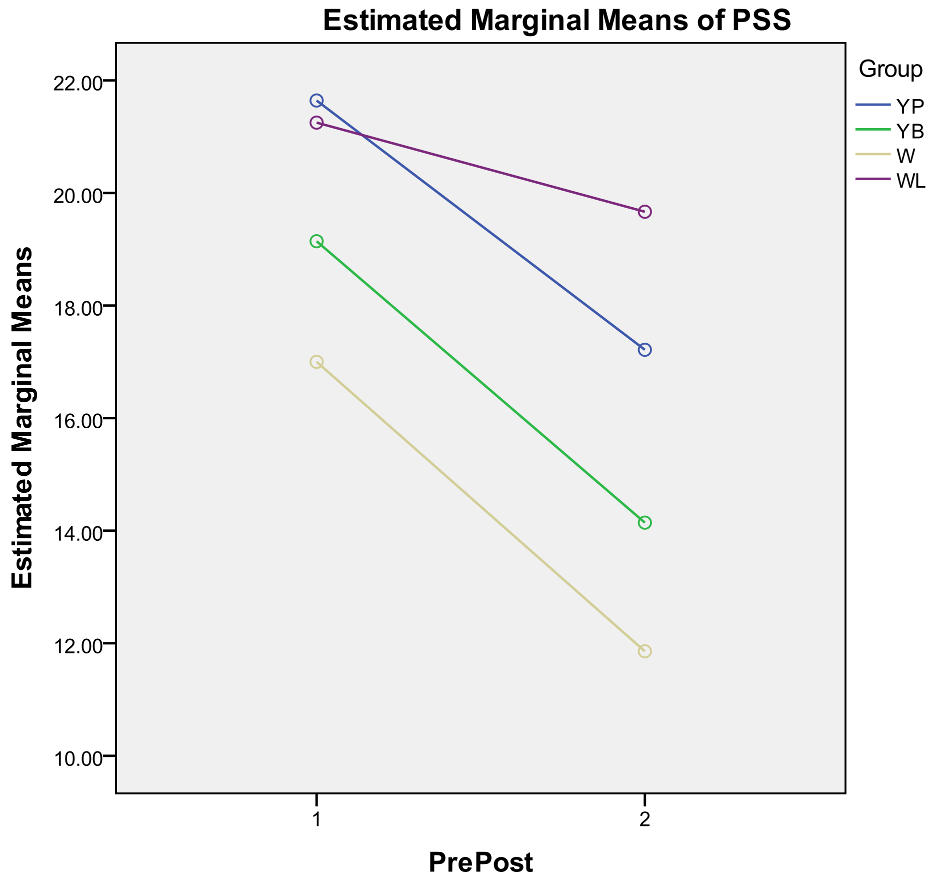

Figure 5. Mean scores on the PSS for the YB (*n*= 14), yoga postures (*n*=14), walking (*n*=7), and wait-listed control (*n*= 15) groups on baseline and post-intervention measurements.

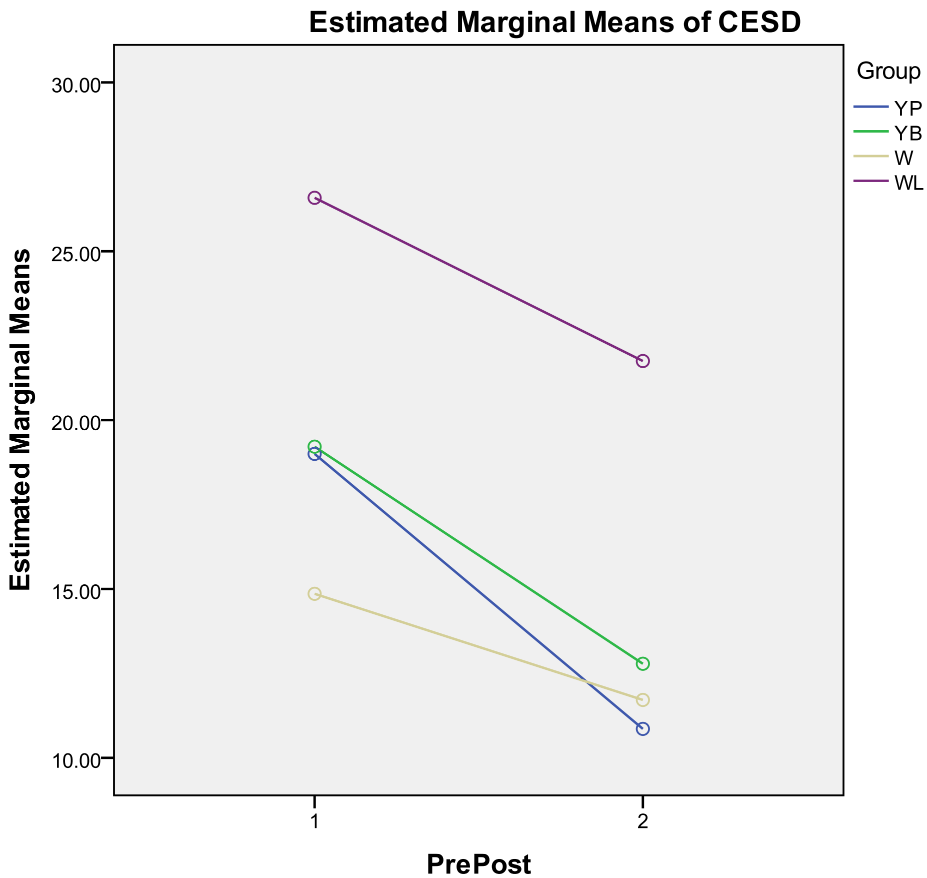

Figure 6. Mean scores on the CESD for the YB (*n*= 14), yoga postures (*n*=14), walking (*n*=7), and wait-listed control (*n*= 15) groups on baseline and post-intervention measurements.

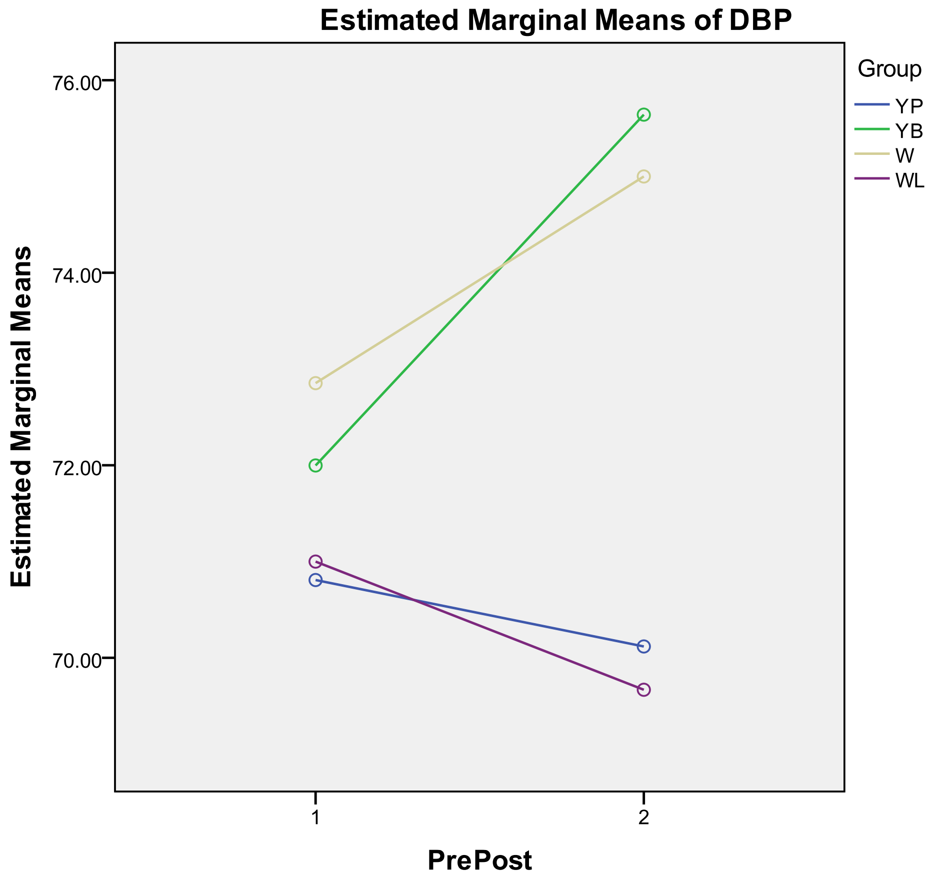

Figure 7. Mean scores on the Diastolic Blood Pressure for the YB (*n*= 14), yoga postures (*n*=14), walking (*n*=7), and wait-listed control (*n*=15) groups on baseline and post-intervention measurements.

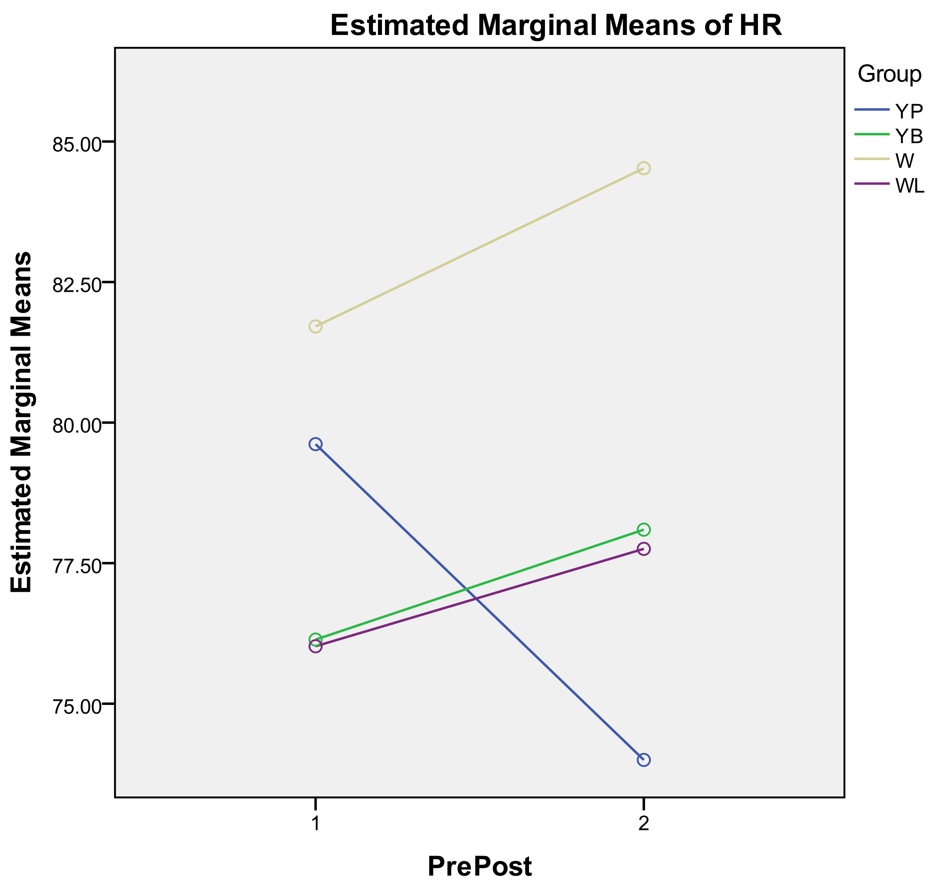

Figure 8. Mean scores on the Heart Rate for the YB (*n*= 14), yoga postures (*n*=14), walking (*n*=7), and wait-listed control (*n*=15) groups on baseline and post-intervention measurements.

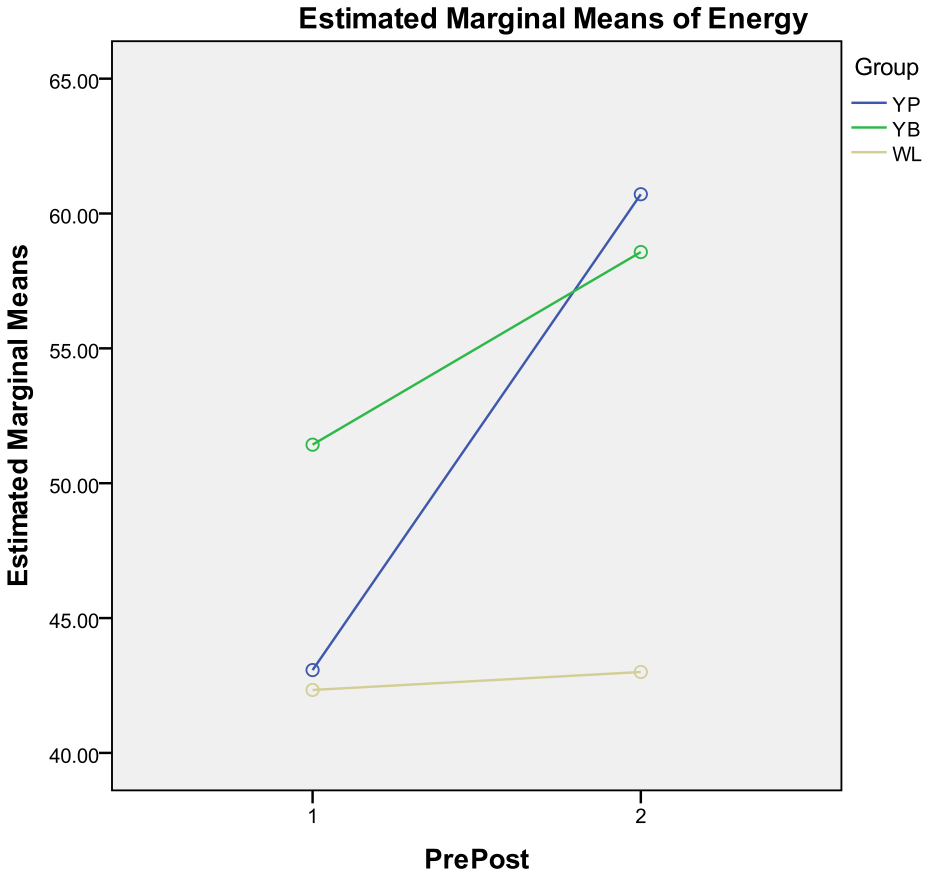

Figure 9. Mean scores on the Energy/Fatigue subscale of SF-36 for the YB (*n*= 14), yoga postures (*n*=14), and wait-listed control (*n*=15) groups on baseline and post-intervention measurements.

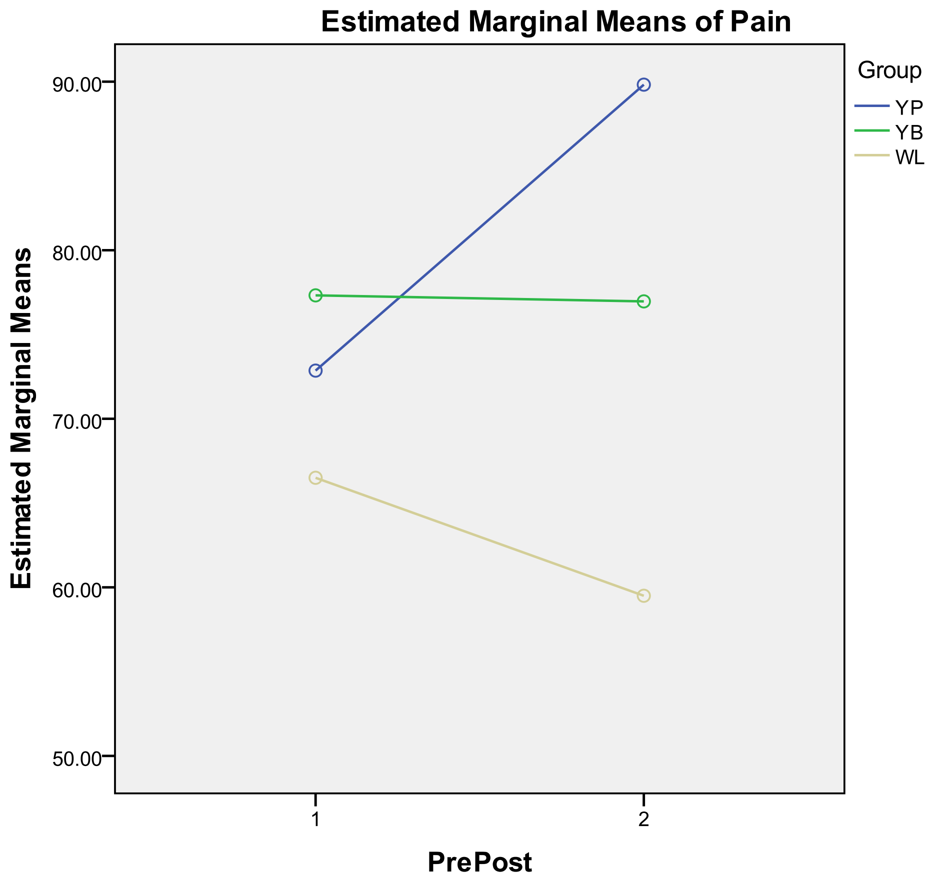

Figure 10. Mean scores on the Pain subscale of SF-36 for the YB (*n*= 14), yoga postures (*n*=14), and wait-listed control (*n*=15) groups on baseline and post-intervention measurements.