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Yoga's Effect on Pain and Functional Disability in Patients With Chronic Low Back Pain: a Literature Review

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Abstract

Chronic low back pain (CLBP) is one of the most prominent causes of functional disability worldwide. A systematic review observed 18.3 percent (±12.7) of survey takers having a current diagnosis of CLBP (11). In the United States, 90 percent of reported cases are deemed unspecific, due to unknown pathologies (31). The estimated cost of treating this widespread disability in the United States is $4.3 billion (18). Due to the prevalence and the associated cost of CLBP, several cost effective alternative and complementary treatments have been found to effectively treat CLBP. Yoga is a common treatment for a number of ailments including migraines, carpal tunnel syndrome, osteoarthritis, multiple sclerosis, hypertension, asthma, irritable bowel syndrome, neck pain, and back pain (24). Yoga is an exercise program focused on improving muscle function and control of the voluntary nervous system (7). Due to its emphasis on the correction of physical causes of pain and functional disability, researchers believe yoga has the potential to be a very cost-effective treatment (4). This Review investigates the effects of yoga on pain and functional disability in patients with CLBP which has made yoga a valuable alternative and/or complementary treatment for patients with chronic low back pain.

Chronic Low Back Pain

Chronic low back pain is described as pain in the lumbosacral portion of the back (disks L1-S5) lasting more than 3-months. There is a wide range of pathologies for CLBP including disc compression, degenerative changes of the lumbar spine and muscular imbalance. CLBP can be a symptom of some serious pathology including fractures, cancer, and various musculoskeletal disorders. Interestingly, 90 percent of CLBP cases are deemed non-specific (31).

There are several known risk factors for the development of CLBP. This first risk factor is age, recent reports found individuals between the ages of 30 and 60 years old have an increased risk of CLBP (11,16). Secondly, CLBP is more common in females than males. Other risk factors of CLBP include history of high-energy trauma, neoplasia, musculoskeletal disorders and declines in general health. Psychological and psychosocial stress, as well as inactivity and obesity have been cited as risk factors for CLBP (16).

Individuals whose career involves manual labor are at an increased risk as well. In a recent study, individuals involved in manual handling, bending, twisting and whole body vibration on a daily bases have an increased risk for CLBP (11). This concurs with a study by Rozenberg and colleagues (2012), which has shown individuals working in manual labor based jobs are at a higher risk for CLBP compared to those with sedentary jobs. Thirty nine percent of the males involved whose careers involved manual labor experienced CLBP, whereas only 18.3% of the males with sedentary desk jobs experienced CLBP. This study's results also are in agreement with the fact that individuals of lower economic and social status tend to have increased episodic durations of CLBP and poor outcomes for treatment (11,16).

Current treatment for CLBP includes medication, exercise and physical therapy. Current European recommendations for medications include non-steroidal anti-inflammatory drugs (NSAIDs), indomethacin, ibuprofen, and weak opioids, codeine phosphate, Tramadol, for short periods (11). Within the first days of onset, range-of-motion (ROM) exercises are the most common treatment. Range of motion exercises reduce stress on the support structures of the spine, increase circulation and maintain flexibility. These exercises have an emphasis on controlled flexion and extension without reaching the end of the range of motion (1). Exercise has been shown to decrease pain, functional disability and improve long-term function. ACSM recommends strength training focused on core and trunk stability. It is suggested that clients under the age of 50 perform 10-15 repetitions per day and those over age 50 perform 8-12 repetitions about 2 days per week. Extreme flexion, extension, and quick movements of the spine should be avoided. Flexibility should be modified to avoid movements causing pain. Finally, aerobic training should be modified to your individual abilities to avoid pain The cardiovascular portion of the exercise prescription should at least consist of a brisk walk 3-5 days per week (3). Chronic inactivity is known to decrease spinal ROM, muscle performance as well as have detrimental psychological effects including increased anxiety and depression (16). Physical therapists employ stretching, strengthening aerobic

conditioning and manipulation techniques in combination with ice, heat, ultrasound and transcutaneous electrical stimulation (TENS) (18).

Physical therapists have access to all types of treatment modalities, however for the most part, require a referral from a primary care or orthopedic doctor. This is due to most insurance companies only reimbursing physical therapists for prescribed treatments. Individuals with Medicaid, and of lower socio-economic status are less likely to receive treatment by a physical therapist than individuals of a higher socio-economic status (18). Because of the difficulty in receiving care from a licensed physical therapist for people of a lower socio-economic status, researchers have worked to find alternative, economically efficient treatments for CLBP. Evidence shows a supervised, individually tailored, high dose stretching and muscle strengthening exercise program is just as effective in the treatment of CLBP. Yoga classes have the potential to be a more economical and widely accessible treatment for CLBP (16).

Chronic low back pain (CLBP) is among the leading causes of functional disability and absence from work worldwide (16). In 2012, systematic review showed a point prevalence in 18.3% of survey takers. This review also observed 50% of the individuals surveyed had a reoccurrence of symptoms within one year and 70% within 5 years (11,16). In the United States, 60-80% of the Population will have experienced some form of low back pain within their lifetime (31). Chronic low back pain not only impacts a person at the individual level but impacts families, communities, businesses and the healthcare system (11). Chronic low back pain is the most expensive problem in healthcare for the 30 to 50 year old age group (7). An estimated $4.3 billion was spent on CLBP treatment in 2005 (18). Pain caused by CLBP leads to functional disability and activity limitations. Participation restrictions lead to absence from work, and therefore, financial burden. The outcome of treatment is dependent on the socio-economic status of an individual and the availability of health care (16). Functional disability and pain resulting from CLBP have a high correlation with psychological disturbances including fear, anger, anxiety and depression (24).

Yoga

Yoga, first introduced in India and described as far back as in the Vedic texts has been practiced for millennia (2). Yoga has been deemed one of the most popular holistic approaches to health in the west, and has been classified by the National Institutes of Health as "a form of Complementary and Alternative Medicine" (31). Practiced by over 14.9 million Americans, yoga has been used in the treatment of various disorders and illnesses including migraines, carpal tunnel syndrome, osteoarthritis, multiple sclerosis, hypertension, asthma, irritable bowel syndrome, neck pain, and back pain (24). Yoga is an exercise that focuses on the control of the voluntary nervous system and muscle function (7). Yoga includes a sequence of postures known as asanas and the control of one's breath while meditating, which leads to a state of relaxation. Yoga's purpose is the achievement of physical, psychological and spiritual wellness by challenging muscular

strength, endurance, flexibility, and balance (2,7). Improvement in both physical and psychological wellness reduces fatigue and stress and increases overall quality of life (2).

The choice of yoga, as a main form of therapy for individuals with CLBP, is because of yoga's ability to minimize, heal and correct the physical mechanical causes of pain and functional disability (31). Yoga has the ability to be individualized. An instructor can target specific weaknesses in each patient, therefore no two patients receive exactly the same care. Astana yoga, which is one form of many in yoga, is commonly used in patients with CLBP. This form of yoga is comprised of 8 limbs and these include the following: moral directives, rules for personal conduct, postures, breath control, sense withdrawal, concentration, meditation and self-realization (2). Astana yoga has been used in several studies to determine of yoga has the ability to decrease pain and functional disability in patients with CLBP (2,13,21,22,29,30). Astana yoga has two branches or subgroups, Viniyoga and Iyengar yoga (2). Viniyoga uses asanas, pranayama (breath control), meditation and lectures on the philosophy of yoga. Iyengar yoga is very similar, however, it has a much greater emphasis on the asanas, the physical postures. Iyengar yoga is a notable form of therapeutic yoga due to its focus on physical postures and use of props. Props such as rope, benches, weights, straps and blocks can provide support to ensure proper form during various postures, and can immobilize joints so specific muscles are targeted (31). Iyengar yoga is the most popular type of yoga practiced in the United States. Created by B.K.S. Iyengar in 1976, this type of yoga stresses exact structural alignment, sequencing of poses and breath control (2).

Hatha yoga and the Integrated Approach to Yoga Therapy (IAYT) have also been used as forms of therapy. Integrated Approach to Yoga Therapy is a type of yoga therapy specifically designed to fulfill the need for an intensive, short-term program to return patients to everyday life as fast as possible. This type of yoga is designed with specific conditions in mind, for example, a special back pain module for CLBP including asanas, pranayama, relaxation techniques, mediation, yogic counseling, chanting, and lectures on yogic lifestyle created specifically for back pain was created for a study analyzed in this report (25). Hatha yoga is a gentle style of yoga that includes postures, mediation, and relaxation (6).

Because CLBP is an exorbitant strain on society due to its prevalence and high cost, it is important to evaluate any potential treatment (4). Yoga administered in a group setting has the potential to be very cost-effective in comparison with various one-to-one treatments such as physical therapy. This paper will discuss several studies that have shown the effects of different types of yoga on pain and functional disability in patients with chronic low back pain.

Methods

Preliminary data was collected by entering "Yoga," "Chronic Low Back Pain," and "Yoga and Chronic Low Back Pain," in the Drake Memorial Library journal article search engine. The results were limited to peer reviewed papers published from 2000 to 2014. Exercise physiology, personal training and athletic training textbooks were also used to investigate primary information about CLBP.

For studies to be included in this paper, they were required to have inclusion criteria of:

1. Age restriction: 18-70
2. Participants with CLBP present for at least the past 3 months

As well as exclusion criteria including:

3. Organic spinal pathologies such as malignancy, nerve root compression, disc prolapse, spinal stenosis, tumor, spinal infection, alkylosing spondylosis, spondylolisthesis, kyphosis or structural scoliosis, or a widespread neurological disorder
4. BMI greater than 39.9 kg/m^2
5. Chronic infections, or critically ill participants
6. Pregnancy

The research examined in this review were required to study yoga's effect on either pain or functional disability, or both, on patients with CLBP. A recognized form of yoga was required including asana, hatha, or IAYT, all of which can be found in Table 2.

The studies chosen were required to measure pain and/or functional disability using some sort of recognized scale. The pain disability scale (PDI) is a seven-item index measured on a 1-10 scale, measures family, home responsibilities, recreation, social activity, occupation, sexual behavior, self-care, and life support activity (10 indicating the worst disability, 0 indicating no disability at all), with a 70 point total (28). The present pain index (PPI) is a 0-5-pain scale indicating pain at the present moment. With five being the worst possible pain and 0 being no pain at all (28). The Owestry disability index (ODI) is a 10 item questionnaire measuring intensity of pain, lifting, ability to care for oneself, ability to walk, ability to sit, sexual function, ability to stand, social life, sleep quality, and ability to travel. Each item is scored on a scale of 0-5, 0 indicating the least amount of disability and 5 indicating the most severe disability. The scores are summed, and then multiplied by 2 to obtain the index (range 0 to 100). Zero is equated with no disability and 100 is the maximum disability possible (7,23). The numerical rating scale for pain is a 10 cm long visual analog scale, the right end being the worst possible pain, the left end being no pain at all (22). The health related quality of life quesitonarrie (HRQOL-4) is a questionarrie that Asks 3 questions in terms of frequency in the last 30 days (>14 equals frequent) regarding physical distress, mental distress and activity limitation (8.9.13.17.24). The visual analog scale is a 10 cm long visual analog scale, the right end being the worst possible pain, the left end being no pain at all (8,13,28). The Roland-Morris disability questionnaire is A 10 cm long visual analog scale, the right end being the worst possible pain, the left end being no pain at all (8,13,28). The Aberdeen

back pain scale (ABPS) The scale includes 19 items of how the pain affects activities including; self-care, walking, sitting, standing, sport, housework, resting, bending and sleep. Each response has graded points ranging 0-5. Possible total ranges from 0 to 100, 0 indicating no affect and 100 indicating the worst affect (24,26). And finally the medical outcomes questionnaire is a 0-20 numeric visual pain scale used to assess self-related disability caused by low back pain (6,17,19,20,24). The scales utilized can be found in Table 1.

The studies were required to have no statistically significant difference in demographics or medical history between the control and experimental groups. Finally, all studies include were required to utilize the appropriate statistical analysis of data collected during the study.

The questions this review of the literature will examine include the following:

1. Does yoga have a significant positive effect on pain level in patients with CLBP?
2. Does yoga have a significant positive effect on functional disability in patients with CLBP?

If the answer is yes:

3. What are the mechanisms causing this effect?
4. Is yoga a more cost-effective treatment than traditional treatment for CLBP?

Table 1: Outcome Measures

Name	Description
Pain Disability Index (PDI)	Seven-item index measured on a 1-10 scale, measures family, home responsibilities, recreation, social activity, occupation, sexual behavior, self-care, and life support activity (10 indicating the worst disability, 0 indicating no disability at all). 70 point total (28)
Present Pain Index (PPI)	A 0-5-pain scale indicating pain at the present moment. 5 being the worst possible pain and 0 being no pain at all (28).
Oswestry Disability Index (ODI)	A 10 item questionnaire measuring intensity of pain, lifting, ability to care for oneself, ability to walk, ability to sit, sexual function, ability to stand, social life, sleep quality, and ability to travel. Each item is scored on a scale of 0-5, 0 indicating the least amount of disability and 5 indicating the most severe disability. The scores are summed, and then multiplied by 2 to obtain the index (range 0 to 100). Zero is equated with no disability and 100 is the maximum disability possible (7,23).
Numerical Rating Scale for pain (NRS)	A 10 cm long visual analog scale, the right end being the worst possible pain, the left end being no pain at all (22).
Health Related Quality of Life Questionnaire (HRQOL-4)	Asks 3 questions in terms of frequency in the last 30 days (>14 equals frequent) regarding: 1. Physical distress 2. Mental Distress 3. Activity limitation (8,9,13,17,24)
Visual Analog Scale (VAS)	A 10 cm long visual analog scale, the right end being the worst possible pain, the left end being no pain at all (8,13,28)
Roland-Morris Disability Questionnaire (RMDQ)	A questionnaire designed to assess self-rated physical disability caused by low back pain (6,17,19,20,24).
Medical Outcomes Study Pain Severity Scale	A 0-20-numeric visual pain scale used to produce an average, worst and total pain score (9)
Aberdeen Back Pain Scale (ABPS)	The scale includes 19 items of how the pain affects activities including; self-care, walking, sitting, standing, sport, housework, resting, bending and sleep. Each response has graded points ranging 0-5. Possible total ranges from 0 to 100, 0 indicating no affect and 100 indicating the worst affect (24,26)
Functional Reach Test	Assesses a patient's stability by measuring the maximum distance an individual can reach forward while standing in a fixed position (3,7).
Sit and Reach Test	Commonly used test for assessment of flexibility of the hamstrings, hips and lower back (3,7).
Back Flexibility in Trunk Extension	Subjects lie in the prone position with hands in a position similar to that of a push-up, subjects push upper-body up as much as possible. The vertical distance from the chin to the ground is recorded (6).

Table 2: Types of Yoga

Name	**Characteristics**	
Asana	Comprised of 8 limbs: moral directives, rules for personal conduct, postures, breath control, sense withdrawal, concentration, meditation and self-realization. Is broken down into 2 branches (2).	
	Iyengar	Utilizes asanas (poses), pranayama (breath control), meditation and lectures on the philosophy of yoga. Has a major focus on asanas and uses several different types of props to ensure proper form and spinal alignment (31)
	Viniyoga	Utilizes asanas (poses), pranayama (breath control), meditation and lectures on the philosophy of yoga (31)
Hatha	A gentle style of yoga that includes postures, mediation, and relaxation (6)	
Integrated Approach to Yoga Therapy (IAYT)	Designed for an intensive, short-term program to return patients to everyday life as fast as possible. Targeted with specific conditions in mind, for example, a special back pain module for CLBP including asanas, pranayama, relaxation techniques, mediation, yogic counseling, chanting, and lectures on yogic lifestyle created specifically for back pain	

Study Results

In this literature review, the following studies were reviewed to determine the effects of yoga on pain and functional disability in patients with CLBP.

In Sherman et. al., (2005), yoga, exercise and a self-care book were compared on their effect on functional disability and medication use for patients with CLBP. In this study the 101 participants were divided into a yoga group (n=36), an exercise group (n=35), and a control group using a self-care book (n=30). The yoga group did 12 weekly 75-minute Viniyoga classes and were asked to practice daily at home. Viniyoga was used to emphasize posture as well as breathing. Five to 12 postures were done per class and were repeated 3 to 6 times. The exercise group included a 12-session class series designed by a physical therapist. This series was different than what most experience in a typical physical therapy treatment program, no ultrasound or but was similar to yoga classes in number and length. An educational talk was given which talked about proper body mechanics and the benefits of exercise. The program included a warm-up aimed at increasing heart rate that included 7 aerobic exercises. The remainder of the program included 10 strengthening exercises emphasizing leg, hip, and abdominal, and back muscles and 12 stretches for the same muscle groups. Over the course of the intervention strength exercises increased from 8 to 30 repetitions. Classes ended with unguided deep slow breathing. The Self-Care book group was mailed a copy of *The Back Pain Helpbook*. This book is used in several studies; it highlights self-care strategies including fitness and strength programs, necessary lifestyle modifications, and strategies for managing flare-ups. Roland Morris Disability Questionnaire (RMDQ), Table 1, scores decreased in all three groups. Compared to the self-care book group the yoga group showed clinically important and statistically significant decreases in functional disability at follow-up points 6, 12, and 24 weeks after randomization. The yoga group had only slightly greater improvements than the exercise group in the RMDQ scores, but the results were statistically insignificant. Seventy-eight percent of the yoga group experienced at least a 2-point drop (minimally significant) in their RMDQ scores compared to the 63% in the exercise group and 47% in the book group. Sixty-nine percent of the yoga groups RMDQ decreased by at least 50 percent, while 50% of the exercise group and only 30% of the book group had reductions this large. "Bothersomeness" of symptoms was rated on an 11-point scale. At the 12-week mark all participants had decreased bothersomeness scores, but only the yoga group had continuous improvements at the 24-week mark. Both the exercise group and the control group's symptoms worsened at this point. Finally, medication use most sharply decreased in the yoga group. Only 21% of the yoga group reported medication use in the week prior to the 24-week follow-up, compared to 50% and 59% in the exercise group and the book group respectively. This study supports the postulation that yoga is a better therapy than exercise and a self-care book for reduction in functional disability, symptom bothersomeness, and pain medication usage in patients with CLBP (21).

A very similar study by Sherman and colleague (2013), compared the effects of a stretching protocol, a yoga protocol and usual care's effect on back related functional disability over a 12 week period and found similar results to the previous study. The 192

participants were divided into 3 groups. The first group consisted of 78 participants participating in yoga, the second group consisted of 74 participating in a stretching protocol and the third group consisted of 40 participating in usual care (2:2:1 ratio). The yoga group completed 75-minute weekly classes, the stretching group completed 75-minute weekly intensive stretching, and the usual care group was given the *Back Pain Help Book*. Results were taken at 6, 12, and 24 weeks after randomization. Compared to the book group, the yoga group showed statistically significant decreases in functional disability at all follow-up points; mean difference in RMDQ scores ranged from 2.6 to 3.6 points. The yoga group and exercise group did not differ significantly in their RMDQ scores (22).

A study, Williams et. al., (2009), compared the effect of Iyengar yoga and a control group on their effects on pain and functional disability in patients with CLBP. Ninety subjects were placed into either the yoga group (n=43) or the control group (n=47). The yoga group's intervention included 24 weeks of biweekly 90-minute yoga sessions and 30 minutes of home practice everyday class was not in session. The control group continued their usual care. Immediately following the intervention, the yoga group reported 42.9% reduction in ODI scores, Table 1, 58.9% reduction in visual analog scores (VAS), Table 1, and the percentage of subjects with clinically important improvements increased by 10% to 12% for the ODI and 8% to 14% for the VAS. There was no significant difference in pain medication usage following the intervention, but there was a trend illustrating slightly larger reductions in the yoga group than the control group. The magnitude of the intervention effect was reported to be small to moderate at the 12-week point (halfway through intervention) and moderate to large at the 24-week point. At the 6-month follow up, no statistically significant changes were found from the 24-week point. Sixty seven percent of the yoga group participants reported continuing the practice of yoga, on average they practiced 3.3 days per week for 32.6 minutes per session. Still no statistically significant reductions in pain medication were found. No statistically significant changes were found in the usual care group. This study supports the hypothesis that yoga is capable of inducing pain reduction and decreased functional disability in patients with CLBP (29).

Williams et. al., (2005), found that yoga therapy delivers greater reductions in functional disability as well as pain level than an educational program. This was a 16-week study comparing an Iyengar yoga therapy to usual care with 2 educational lectures. Twenty four participants receives a yoga intervention, which was a 90-minute per week class that included 29 postures aimed to lengthen constricted muscles and strengthen core postural muscles. Participants were also encouraged to practice for 30 minutes at home for 5 days per week. Twenty participants were in the usual care group. Both the yoga and usual care groups, prior to the intervention, received 2 1-hour lectures on occupational and physical therapy education regarding CLBP. After the 16-week intervention the functional disability score measured with the PDI, dropped 76.9% in the yoga group and 39.6% in the control group. At the 3-month follow up the yoga group reported a 72.7% decrease from the baseline in PDI, and the control group reported a 30% decrease. Interestingly the VAS score did not become significant until he 3-month follow-up when the yoga group reported a 70% decrease in pain while the control group reported a 38% decrease. The yoga group also reported two times the decrease in PPI scored of the

control group. Immediately following the intervention the yoga group reported 88% of subjects had either decreased or stopped using pain medications all together compared to the 35% in the control group. At the 3-month follow up both groups reported further decreased pain medication usage, but the yoga group continued to have significantly greater decreases than the control group. Significant reductions in the PDI, PPI, VAS, and pain medication usage at the post assessment and the 3-month follow up assessment indicate yoga causes a significant reduction in pain and functional disability for patients with CLBP (30).

An intensive study completed in Bangalore, India, Tekur, et. al., (2008), comparing a usual care intervention to a IAYT intervention found statistically significant reduction in ODI scores for the IAYT group, and no significant changes in the usual care group. This study had 45 participants in the yoga group, and 46 participants in the usual care group. Patients in this study were admitted to a health home where their days were scheduled by the hour. The IAYT group's intervention included *om* meditation, yoga based special techniques, yogic hymns, lectures, deep relaxation techniques, yogic breathing exercises, cyclic meditation, counseling and mind sound resonance techniques. The yoga based special techniques progressed from initial safe movements to final more difficult yoga postures providing a tractionlike effect. The usual care group's intervention matched the yoga group's intervention by the hour, the differences being a set of nonyogic physical exercises for CLBP, and non-yogic breathing exercises. The ODI scores in the yoga group showed a 48.76% decrease in disability, indicating a decrease from moderate to mild disability. The usual care group showed no significant changes in ODI. Spinal flexion, extension, right lateral flexion and left lateral flexion improved significantly in both the yoga group and the usual care group. This study endorses the notion that yoga has a greater effect on functional disability than a traditional exercise program (25).

A randomized trial for a 12-week yoga program, Tilbrook et. al, (2011), found that significant functional disability reduction was found following a 12-week yoga intervention. One hundred and fifty six participants were in the yoga group and 157 participants were in the usual care group, which received a back pain education booklet. The yoga group participated in a 75-minute class once per week and were given practice sheets to practice 30 minutes daily or 2 times per week. The yoga program was a mix of the principle foundations of yoga including asana, pranayama, relaxation techniques and mental focus specifically created for CLBP. The usual care group was asked to go about their usual daily lives. Compared to baseline scores, RMDQ scores for the yoga group were reduced significantly by 2.71 points immediately following the intervention (3-months), 2.42 points lower at 6-months, and 2.04 points after 12-months. The usual care group had no significant changes in RMDQ scores. There was no statistical significance in ABPS scores between the yoga and usual care groups. This study suggests yoga is capable of decreasing functional disability, but not pain in patients with CLBP (26).

Cho and colleagues, (2014), studied the effect of a hatha yoga treatment plan on premenopausal women with CLBP. The 14 participants in the yoga group completed a 12-week hatha yoga regimen. The 60-minute class was comprised of warming-up, yoga-poses, and relaxation and was completed 3 times per week. Twelve yoga poses with

increasing difficulty were used and participants were asked not to practice at home. The usual care group's 11 participants were asked not to change their daily activities over 12-weeks. The RMDQ scores for the yoga group dropped by an average of 1.3 points. While this is a small reduction, back flexibility in the yoga group increased significantly by an average of 5.2 cm. No significant differences were found in either measure for the usual care group in either measure. This study indicates a 12-week hatha yoga program is capable of small reductions in functional disability and significant improvements in back flexibility for patients with CLPB (6).

A 2014 study, Nambi and colleagues, (2014), found that pain, physically unhealthy days, and activity limited days dropped significantly following a 4-week Iyengar yoga intervention. In this study, 60 participants were split evenly into a yoga group and an exercise group. Both groups received a 1-hour lecture on physical therapy education regarding CLBP 2-weeks prior to the interventions start date. The yoga intervention involved attending yoga class 60 minutes per week for 4-weeks along with yoga practice at home for 30-minutes 5-days per week. The general exercise group was taught specific exercises designed for strengthening and stretching the abdominal and back musculature. These exercises were practiced for 3-days per week with 5-repitions, 3-sets with 30-second rests between. Gradually the repetitions were increased to 15 over the 4-week period. From baseline to post-intervention, the yoga group's average pain intensity score on the VAS decreased 43.54% and after 6 months had dropped 72.81%. The exercise group average VAS scores decreased by 21.25% immediately following the intervention, and after 6 months had decreased 42.50%. Physically unhealthy days measured using the HRQOL questionnaire also decreased significantly for both groups. The yoga group had a 5.37% decrease after the 4-week intervention, and 85.61% decrease by the 6 month follow up. The exercise group had less of a severe decrease in physically unhealthy days; a 39.7% decrease was reported immediately following the intervention and a 61.04% reduction at the 6-month follow-up. Finally, the yoga group had a 55.08 percent decrease after the intervention and an 87.53% decrease at the 6-month follow-up. The exercise group reported 29.69% reduction in activity-limited days immediately following the intervention and a 70.59% reduction 6-months later. This study indicates yoga is a better form of therapy for reduction in pain than general exercise (13).

Tekur and colleagues, (2012), also found yoga to be a prudent way to reduce pain in patients with CLBP. This study found that with careful body movement together with active mindfulness, deeper relaxation was promoted and spinal and abdominal muscles can be strengthened. This was a weeklong study comparing the effects of yoga and physical therapy on pain in patients with CLBP. The 40 participants in the yoga group partook in 7 days of the IAYT. This intervention is focused on relaxing the spinal muscles through stretches of the paraspinal muscles, then providing a traction effect on the spine and finally strengthening the lumbar and abdominal muscles. Integrated Approach to Yoga Therapy's utilization of pranayama reduces breath frequency in order to encourage control of ones emotions and lectures help participants improve stress management skills. The exercise group's day matched the yoga group's day hour for

hour. This group practiced physical therapy movements, non-yogic breathing exercises and scientific lectures on the cause of back pain, stress and CLBP and the benefits of physical exercise. The yoga group experienced a 49% decrease in pain on the NRS, while the physical exercise group experienced a 17.5% percent decrease. This study substantiates the argument that yoga is more efficient in alleviating pain in patients with CLBP (24).

Groessl at. al., (2008), a study done on yoga for veterans with CLBP statistically significant decreases in pain were found. Anusara yoga (a type of hatha yoga) was utilized in this 10-week yoga intervention, patients completed 8 sessions. Thirty-two poses were chosen specifically for patients with CLBP. Pain was measured using the VAS and a 5-question severity scale, and average pain scores dropped 9.57 points in the yoga group. This significant improvement in pain was found along with a correlation between actual attendance and decreased pain. This likely represents a "dose-response" treatment effect. No significant changes were found in HRQOL physical composite score (8). In a similar study comparing female and male veterans recovery from CLBP using yoga therapy, Groessl et. al., 2012, it was found that women had slightly greater improvements in pain "on average" but no differences were found in pain "at its worst" or "total pain" from the Medical Outcomes Study pain severity scale. Average pain scores on the Medical Outcomes Study pain severity scale by 0.6 points for males and for females by 1.4 points. This study included 40 males and 13 females (9).

The pilot study, Galantino et. al., (2003), found only slight improvements in functional disability. This study included 22 participants, 11 in the control group and 11 in the yoga group, aged 30 to 65 years old. One-hour yoga sessions were administered 2 times per week during the 6-week intervention. Participants were asked to complete 1-hour per day as well. The control group was asked to continue with their usual everyday activities. No statistically significant changes were found in the ODI. However, in the 3-month follow up 54% of participants reported improved low back pain since completion, compared to 20% in the control group. The participants also took part in a functional reach, and a sit and reach test following the intervention. The 64% of the experimental group improves in the functional reach, 90% improved in the sit and reach, while only 20% of the control group improved in either. This study demonstrates yoga can produce improvements in flexibility and reductions in pain in patients with CLBP. The effects on pain should be reviewed cautiously however as this was a pilot study with a small subject pool (7).

Saper et. al., (2009), was a 12 week hatha yoga study in a predominantly minority population. While this was a pilot study, it had interesting results that will hopefully be looked into further in the future. All 30 participants (n=15 for yoga group, n=15 for usual care group) received an educational book that describes self-care management strategies for low back pain. The yoga group also took part in 12 weekly 75-minute yoga classes. These classes included postures and breathing techniques. Participants were encouraged to practice at home for 30 minutes daily. After 6 weeks minimal clinically significant pain reductions were found in both average pain for the previous week (measured on 11-point numerical scale) and in RMDQ scores. These scores improved further into week 12.

A small percentage of the usual care group also had minimal clinically significant improvements in pain and functional disability after the 12-week intervention. The yoga group's percentage of participants using medications dropped from 67% to 13%, the usual care group experienced no change. This study is interesting because in this population considerably greater pain and worse function were reported prior to the intervention than other studies (17).

Discussion:

Yoga's Effect on Functional Disability

Functional disability is one of the substantial impacts of CLBP (11). Functional disability was measured using several different tests including the RMDQ, PDI, ODI, the physically unhealthy days and activity limited days portions of the HRQOL questionnaire, and flexibility measured with spinal range of motion, the sit and reach test and the functional reach test (Table 1). These tests measure a person's ability to complete activities of daily living. In 7 of the 8 studies that measured functional disability, significant decreased in functional disability were reported (6,7,21,22,25,26,29,30). Galentino et. al., 2003 was the only study measuring functional disability that did not find improvement; it did however indicate improvement in the functional reach and sit and reach tests (7). This study was a pilot study with a small subject pool, so its results should be cautiously interpreted. Overall the decrease in functional disability and increases in flexibility following a yoga intervention was greater than that of an education intervention, general exercise program, a stretching protocol, or usual care (21,29,30,25,26,22). All of the studies that measured functional flexibility found statistically significant increase. A substantial reduction in functional disability with significant increases in flexibility is a interesting finding. Spinal flexibility is likely an important mechanism in functional disability reduction, which will be discussed later in this report.

Yoga is a multidimensional therapy; there are several aspects of life that it can positively impact functional disability. All of the reviews above found minimal to moderate decreases in functional disability with various yoga programs. No specific type of yoga proved to be significantly superior in this review. Sherman et. al., (2013), delineated the individual components of the RMDQ, Table 1, to find the proportion each variable attributed to improvements in functional disability. Improvement in self-efficacy attributed 36% of the benefit of yoga, decreased sleep disturbances due to back pain attributed 18%, and increased hours of back exercises performed in the past week attributed 9% (22). This suggests the psychological aspects of yoga are as important as the physical aspects in yoga's rehabilitative abilities. These significant reductions in functional disability following a yoga intervention have been reported to last as long as 12-months (26); but appear to be most prominent immediately following an intervention and up to 3-months later (29,30,26,22,13).

Yoga's Effect on Pain

Research shows pain is associated with sensory, affective, behavioral, and cognitive factors. There is some variation in recent research's findings on the effect of yoga on pain in patients with CLBP. Pain was measured using bothersomeness, VAS, ABPS, NRS, (Table 1) and pain medication usage. The majority of studies show significant decreases in pain and pain medication usage. Eight of the 9 studies reported significant pain reduction (8,9,13,17,21,26,29,30). Tilbrook and colleagues (2011), was the only study that reported no significant pain reduction following a yoga intervention.

Although this study reported no pain reductions, it did report increased confidence in performing activities of daily living despite back pain (26). Overall it is evident that yoga has the ability to reduce pain in patients with CLBP. These results have been reported to last as long as 6-months as well following a yoga intervention (13).

Mechanism for yoga's improvement in pain and functional disability

It is evident from the above literature review that yoga therapy is capable of pain alleviation as well as significant decreases in functional disability. Chronic low back pain is a complex condition, involving bone, ligament, joint capsules, muscles, tendons, and both the central and peripheral nervous systems. Yoga is a multidimensional intervention; the physical effects of exercise, breathing, and concentration contribute to the deep relaxation of core musculature and conscious awareness of the body's posture and alignment, which is hypothetically necessary to alleviate the symptoms of CLBP (25,28). Yoga's emphasis on awareness, concentration, and bidirectional communication between the mental, nervous, and musculoskeletal systems make it the ideal therapy for CLBP (24).

The core acts as a kinetic chain for the transfer of force from the distal limbs throughout the body. The muscles of the hip support the trunk structures and play a key role in the transfer of force from the lower extremities up through the spine (14). Causes of weak of imbalanced trunk musculature range from muscular atrophy of the paraspinal muscles caused by prolonged improper postures during a sedentary lifestyle to excessive loads on the lumbar spine (14,25). A study done by Ni and colleagues, (2014), assessed 11 yoga poses via examination of muscle activation patterns in specific trunk and hip muscles using electromyographic (EMG) signals. This study found that diverse trunk and pelvic positions utilized in yoga cause variations in core musculature firing patterns. For example, high plank, low plank, and downward facing dog poses all increase muscle activation, and therefore strengthen the external oblique abdominis; the chair and warrior I poses target the gluteus maximum; the chair and halfway lift poses strengthen the longissimus thoracis; and the upward facing dog utilized all of the muscles above. This shows that training programs can be developed by choosing to target specific core muscles for addressing weakness and imbalance in core and back musculature attributing to CLBP. By strengthening these specific muscles, pressure on the spine can be reduced. This is a possible mechanism for both pain and functional disability reduction following a yoga intervention for patients with CLBP. This study also shows the level of activation yoga induces is enough to generate improvements but not enough to risk injury, ensuring this is a safe form of therapy (14).

Postures in yoga, especially the more advanced poses, usually require isometric contraction of the muscles, and coordinated movement of agonist and antagonist muscles called reciprocal inhibition. Proprioceptive neuromuscular facilitation (PNF) is also utilized in yoga; which involves isometric contraction of the muscles while they are being lengthened (1). These muscle contractions in a lengthened position allow muscles to increase in both flexibility and strength. Yoga postures lengthen, and reeducate all muscles that cause aggravation of the lower back to reinforce proper motor patterns. Lengthening of the back extensors muscles decreases compression on the lumbar spine

(31). Reeducation of muscle firing patterns allows weak muscle to be strengthened and overused muscle to be rested. It takes about 8 weeks for neurological adaptations to take place and allow for increases in strength (1). Stronger and more flexible musculature is a possible cause of the decreases in functional disability (1,3,14,22).

Yoga affects the mind and spirit along with the physical experience of pain. The reason yoga is may be more effective than general exercise programs stems from the careful body movement along with active mindfulness; together promoting increased strength in the core musculature and promoting deeper relaxation. Cognitive-behavioral therapy studies have shown pain perception can be impacted by self-efficacy (16). Similarly, the results of this review found that yoga induces improvement in the participant's ability to perform activities of everyday life (22,26). Cognitive-behavioral therapy combines education, reframing beliefs, forming new coping mechanisms and stress management. This form of therapy has seen greater improvements in pain levels than standard care. The yogic breathing and *Om* meditation work in a similar manor, allowing patients to learn new ways to deal with emotional stress through cognitive behavioral changes. (16). Participants in the study conducted by Tekur and colleagues, (2012) reported after participating in yoga they acquired the mental relaxation necessary to recognize suppressed negative emotions and work through them. This study also showed there was a 16% decrease in anxiety following a yoga intervention. The positive impact yoga has on pain reduction has been argued to be a cause of an increase in endorphin production at the cortical level, which is associated with decreased anxiety and mental relaxation (24). Yogic breathing can have a relaxing effect on the sympathetic nervous system, causing reduction in stress and pain (25).

Recommendations for Yoga Therapy

Yoga has potential to be a successful complementary therapy for the reduction in pain and functional disability in patients with CLBP. Based on the review above, these are the recommendations for the design of a successful CLBP based yoga program. Yoga therapy for the treatment of CLBP should always begin with an evaluation of a participant's medical history. It is important to ensure no serious medical pathology is found as the root of the problem, therefore a physician should clear the patient before they begin any form of therapy. Next the instructor should perform an evaluation. The best way for an instructor to test for signs of dysfunction and muscular imbalance in a specific area of the back is to have the participant perform tâdâsana (mountain pose). This is a basic standing pose that can determine problems with the musculature of the feet, legs, knees, hips, trunk, chest, shoulders, and neck, and how this affects posture, alignment of the spinal vertebrae, and gait (31).

The sequencing and timing of poses are key factors in the creation of a yoga program for what or whom. It is important to progress from easy to more complicated, traction inducing postures. Beginning with poses aimed at relieving pain and muscle tension, these postures are usually passive and in the supine position. An example of this is Supta-Pavanamuktasana, Table 3. Breathing and relaxation is key in stretching and removing tension from the musculature. From here a progression is made to postures specifically designed to lengthen musculature that attaches the spine to the pelvis with the

spine fully supported as it is in Uttanapadasana, found in Table 3. Finally standing poses are introduced which open the hips and teach participants to use the limbs to lengthen spinal and pelvic musculature (30). The most difficult poses are standing and require stabilizing muscles to work actively against gravity (31). B.K. Iyengar, the creator of Iyengar yoga, has said the challenge in obtaining correct alignment in standing poses is crucial for recovery in patients with CLBP (13). Twisting motions are then used to reach deeper layers of the spinal musculature, realign vertebrae, and create a traction like effect increasing vertebral disc space. Inversion poses, are important for reversing the damaging effects gravity has on the spine (30,25). Examples of popular poses designed for CLBP can be found in Table 3 in the appendix. Every session should end with passive postures to cool-down the body and allow for mental relaxation. It is important to return the heart rate to normal, and allow time for breathing exercises (13, 31). A minimum of 12-weeks should be allotted to allow for the reeducation, strength gain, and increase in functional flexibility needed to alleviate the symptoms of CLBP. A 75-minute weekly class, paired with 5 additional days of 30-minute practice at home. It is important to have weekly classes, as ensuring participants are utilizing proper form is very important for safety and progression. Participation at home is safe as long as the participant is instructed on form very specifically, and is given a protocol to follow (24). As for the type of yoga, to date there is no study comparing the different styles and their effects on CLBP. This is something that should be studied in the future.

The initial poses should be held for a short time to increase mobility, about 15 to 20 seconds with about 8 repetitions to avoid soreness. In order to increase strength and flexibility the timing should increase. Increasing to 1 to 2 minutes with fewer repetitions increases strength inducing proper anatomical alignment (31). Postures should address the superficial layers at the site of the imbalance or weakness and move to deeper more challenging poses. It is important to avoid back flexion, extension, or sudden movements to avoid further injury (30). Instructors should correct form and watch for muscular imbalances to avoid further injury. Cognitive awareness and control are of the upmost importance in achieving proper form (31).

Participants with hypermobility should be taught techniques to strengthen and improve control of the muscles in the low back and pelvis. Musculature in the pelvic girdle, including muscles of the abdomen, hamstrings, quadriceps, hip adductors and lateral rotators, buttocks, and of the lumbar and thoracic areas of the back should be targeted in CLBP yoga therapy programs. Stronger and larger peripheral muscles frequently overpower small muscles; therefore deep muscles of the back, including the erector spinae and transversospinalis muscles need to be strengthened, while larger muscles are reeducated. This task is accomplished at first using props to ensure proper form, followed by independent action done by students as they learn how to align their bodies to create stability (31).

It is important that instructors are aware of the level of pain the participant is feeling. If pain levels are high the participant will be unable to focus on control of the body and maintaining proper form. When pain levels are high passive postures are best. Passive postures allow the participant to gain a better understanding of the alignment of the body and help improve control (31). The program should target many muscle groups with various categories of yoga postures to promote balance and mobility in the spine,

and strengthen those that are underutilized.

Is Yoga a cost-effective treatment?

For individuals without access to adequate health-care, yoga is absolutely a more cost-effective treatment for CLBP. Yoga is a therapy that can be used safely in a home environment, so long as weekly visits to a professional are added. Once proper form and timing is learned, it is safe to practice at home for the majority of yoga sessions. A professional instructor will be needed only weekly, or even bimonthly, to track progression and remind participants of proper form (25). Because yoga is taught in a group setting, its cost per session is less expensive than a one-on-one session in physiotherapy (4). This therapy is safe for use in individuals aged 18 to 70 years old, people of all socioeconomic statuses and is available all over the country (25). Yoga is a potentially cost-effective treatment; however further research is necessary to compare its cost to its actual value as a therapy tool.

Future Studies

Limitations found in the studies reviewed should be addressed in future studies. This review has large variability in type of yoga employed and size of population studied. Several studies included in this analysis had small sample sizes ranging from 14 to 22 participants (6,7,8). A larger sample size will more reliably reflect the population. The studies used in this analysis were not repeated. It is important that there are repeats in the future to increase the chance of statistical significance, allowing certainty in the results. This analysis explored studies that utilized Iyengar yoga, Viniyoga, Hatha yoga, and IAYT. Each of these forms of yoga is similar in that they utilize the basic principles of yoga, but they vary slightly. Based on this review it can be said that yoga in general has a positive effect on pain and functional disability in patients with CLBP, however, no significant evidence that one type of yoga is superior in the treatment of CLBP was found. Future studies should compare individual styles of yoga on their effects on patients with CLBP. Future studies should analyze which form of yoga has the greatest impact on CLBP. Another limitation found in this review was variability in baseline characteristics between studies. Saper et. al., (2009), a study done on a predominantly minority population examined the effect of a hatha yoga protocol compared to usual care found that it's participants had significantly higher pain levels and functional disability scores at baseline than the majority of other studies completed (17). This is in contrast to Williams et. al., 2009, recruited its participants through self-referral, in this case baseline measures for pain and functional disability were significantly lower than in other studies (29). This reduces the absolute magnitude of improvement each study and limits the generalizability of their results. In several of these studies, the control group is a usual care group. It is difficult to control a usual care group and difficult to eliminate bias. For example, some patient's usual care could include a variation of medications, while another patient in the same study has not been prescribed any medication (7,30,26). In these cases some of the usual care participants reported improved symptoms. This is likely due to bias from phone calls and questionnaires (26).

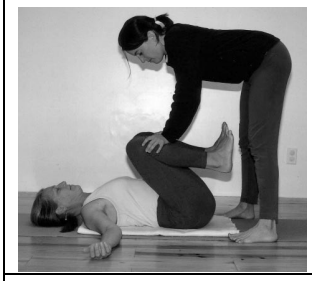
Electromyography is a form of technology used to record the electrical activity produced by skeletal muscles. As seen in Ni et. al., 2014, EMG can determine the muscle firing patterns in different movements. This study showed the muscle firing patterns in healthy individuals with experience with yoga (14). This type of technology has not been used in any studies examining patients with CLBP. Future studies should use EMG to further examine causes of CLBP, yoga's mechanism in alleviating pain and functional disability, and for the creation of individualized programs targeted at the individuals weakness.

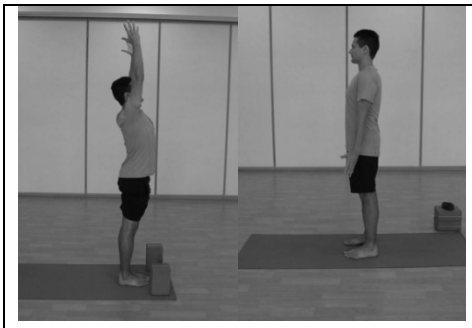
Conclusion

In conclusion, yoga is a multidimensional form of rehabilitative therapy that has a potential impact on pain and functional disability in patients with CLBP. Despite the limitations of this review, it is feasible that this is an economical alternative therapy for a large variation of individuals suffering from CLBP. Future studies should have more control over the usual care group; have a larger sample size; and should examine the mechanisms in which yoga decreases pain and functional disability, as well as the most efficient and effective forms of yoga for CLBP rehabilitation.

Appendix

Table 3: Popular Yoga Poses

Pose	**Mechanism**
Supta-Pavanamuktasana 	Posterior pelvic tilt creates internal traction and lengthens the muscles connecting the pelvic girdle to the spine (31).
Uttanapadasana (straight leg raise pose) 	Lengthens the muscles connecting the pelvic girdle to the spine (24).
Vyaghra Svasa (Tiger Breathing)  	Provides traction and strengthens lumbar and abdominal muscles (24).
Mountain Pose	Designed to elevate the back, open the pelvic region, and compress the ribcage to increase stabilization (14).

	
Warrior 1 pose 	Constant contraction of the longissimus thoracis maintains limited back extension, inducing increased muscular endurance (14)
Standing Tree Pose 	Constant contraction of stabilizer muscles increased muscular endurance, lengthens external rotators of the hip (7)
Triangle Pose 	Increases length of lateral flexors of the spine, creates traction like effect (7)
Lateral Arc Pose	Provides a traction like effect (24).

	
Shavaudarakarshanasana (crossed leg lumbar stretch) 	Reaches deeper layers of the spinal musculature, realigns vertebrae, and create a traction like effect (24,30)

Resources

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