Summer 6-5-2016

1st Place: The Effectiveness of Yoga Therapy on an Adult, Post-Stroke Population: A Systematic Review (Final Research Paper)

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Comments

Baylor Hogan won First Place in the 2015-2016 Kevin and Tam Ross Undergraduate Research Prize for her essay about the effects of yoga therapy on the physical and mental wellbeing of stroke patients. This essay is the original scholarship that emerged from that research.

The Effectiveness of Yoga Therapy on an Adult, Post-Stroke Population: A Systematic Review

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May 2016

ABSTRACT

Objectives: The objectives of this paper are to (1) give a brief overview of stroke pathophysiology (2) outline yoga as a therapeutic strategy (3) present the current research on yoga rehabilitation for stroke (4) discuss the efficacy of yoga for chronic stroke.

Methods: Relevant terms were searched in PubMed, Web of Science, Academic OneFile, ScienceDirect, and Google Scholar electronic databases. Studies were excluded if they contained pediatric stroke, non-stroke neurological diseases, or subjects with comorbidities. Statistically significant data was extracted for the primary measures of nine trials.

Results: Four studies measured statistically significant outcomes ($p<0.05$). These included improvements in balance, independence, endurance, trait anxiety, fear of falling, self-efficacy, pain, strength, range of motion (ROM), activity, participation, and quality of life (QoL).

Discussion: Lack of statistical significance in post-stroke depression (PSD) measures may be due to inadequate intervention length or a psychosocial cause of depression. Improvements in balance, flexibility, and strength from yoga participation permitted progress in disability and functionality. Finally, overall health-related quality of life (HRQL) is affected by the severity of mental disorders and physical disability. Yoga can have a positive effect in both domains and therefore, may improve HRQL.

Conclusion: Preliminary evidence suggests the benefits of yoga on depression, disability, and HRQL. Further research needs to be conducted to determine the efficacy of these findings in treating chronic stroke.

Key words: stroke, post-stroke, rehabilitation, yoga, health-related quality of life, disability, depression

INTRODUCTION

Stroke is the second leading cause of death and a primary cause of disability in adults worldwide.[1] In the United States alone, there are over 4.5 million stroke survivors.[2] The term "stroke" can be defined as a noncommunicable disease characterized by a blockage of oxygen-rich blood flow to an area of the brain.[3,4] Significant clinical, social, and economic implications have accompanied the growing incidences of stroke, and demand attention from health care professionals.[5] As the pathophysiology of stroke is becoming increasingly understood, treatment techniques are improving. However, a limited amount of research currently exists on successful treatments and preventative protocols, thus limiting the rate of treatment advancement. The primary objectives of this review are to: (1) give a brief overview of stroke pathophysiology (2) outline yoga as a therapeutic strategy (3) present the current research on yoga rehabilitation for stroke (4) discuss the efficacy of yoga for chronic stroke (>6 months).

Pathophysiology of an ischemic stroke

The pathophysiology of stroke is complex and well beyond the scope of this paper, however a brief overview of stroke development is included. An ischemic stroke occurs when an artery carrying blood to the brain is blocked or disturbed.[3] Consequently, the delivery of oxygen needed for neuron survival is halted causing cell injury or death.[6] Neurons do not regenerate, therefore dead cells, and their function, are permanently lost.[6] Ischemic strokes account for the majority of occurrences and include thrombotic stroke, embolic stroke, systemic hypoperfusion, or venous thrombosis.[5] A thrombus refers to a clot that forms in the region where the vessel is blocked, whereas an embolus is a clot that forms in one location but travels via the circulatory system to another, smaller vessel.[7] The final classification of ischemic stroke is systemic

hypoperfusion and is often due to a cardiac dysfunction that causes multiple areas of hypoxia in the brain.[5]

Hypoxia causes cytotoxic edema, which can develop into vasogenic edema, and a decrease in structural integrity that results in the breakdown of the blood brain barrier.[5] Within minutes of a stroke, cellular edema causes swelling of the neurons, glia, and endothelial cells in the brain.[5] Further complications may arise from an increase in intracranial pressure as macromolecular serum proteins experience an increased permeability due to vasogenic edema.[5] At the cellular level, activation of the ischemic cascade depletes local oxygen and glucose causing a halt in ATP production needed for cell survival.[5] Without oxygen and glucose, the neuron membrane cannot preserve the ionic gradient causing cell damage and death.[5] The consequences of a stroke depend on the affected region of the brain and the amount of tissue that undergoes immediate death.[5]

Pathophysiology of a hemorrhagic stroke

Hemorrhagic strokes occur when an aneurysm or arteriovenous malformation (AVM) ruptures, and floods the brain with blood.[6] An aneurysm forms when a weakened blood vessel wall balloons out, fills with blood, and can easily burst.[6] An AVM is a rare genetic condition where the veins and arteries are directly connected without a capillary bed buffer in between.[6] Over time, the veins cannot sustain the high pressure from the arteries and the connection breaks causing blood to leak into the brain.[6]

Depending on the location of the ruptured vessel, the stroke will manifest as an intracerebral hemorrhage (within the brain) or a subarachnoid hemorrhage (outside of the brain).[5] Adverse effects of a hemorrhagic stroke are due to hypoxia, the toxic effect of blood on neurons,

and increased intracranial pressure.[5,6] Hemorrhagic strokes can have a devastating effect on the brain. Although, they account for only 10-25% of total strokes, hemorrhagic strokes cause 40% of all stroke deaths.[3,5]

Risk factors and warning signs

Lack of awareness and an increasing trend toward a western diet and lifestyle puts many people at risk for stroke. Some risk factors are innate and cannot be controlled, but others are due to poor lifestyle choices. Table 1 outlines the known risk factors associated with stroke.[4,7,8]

Uncontrollable	Controllable
• Age • Family History • Race • Gender • Previous Stroke or Heart Attack • Sickle Cell Disease	• High Blood Pressure (hypertension)* • Smoking, Alcohol, Drug Abuse • Diabetes Mellitus • Cardiovascular Disease (CVD) • Atherosclerosis • High Cholesterol • Poor Diet • Physical Inactivity • High Levels of Stress • Depression

Table 1: *Uncontrollable and controllable risk factors associated with stroke.*[4,7,8]
*The most important risk factor to be aware of and the leading cause of stroke.

High blood pressure can indicate a variety of complications including atherosclerosis and CVD. Atherosclerosis, a direct precursor to a thrombotic or embolic ischemic stroke, develops over a long period of time and may present itself in the form of a fatty streak, lesions with extracellular lipid, or fibrous plaque.[5] The progression of atherosclerosis is as follows: (a) injury to arterial wall (b) foam cell transformation (c) oxidation of LDL-cholesterol by free radicals (d) smooth muscle cell proliferation (e) platelet adhesion (f) plaque fissuring and the formation of a

thrombus.[5] A further pathophysiological breakdown of the atherosclerosis event sequence can be found in Deb et al 2010.[5]

Stroke is a medical emergency and time is a critical component. Symptoms of a stroke include sudden weakness, paralysis, numbness, trouble speaking, understanding speech, aphasia, or seeing.[4,7] The warning signs of stroke can be remembered using STROKE as an acronym: Speech (any language problems), Tingling (or numbness), Remember (memory deficits), Off balance, Killer headache, Eyes (vision problems).[6]

Post-stroke effects

The result of an acute stroke is neuronal death and loss of physical and mental function.[5] Post-stroke depression (PSD) is the most common neuropsychiatric complication and is seen in approximately one-third of stroke survivors.[2] Subsequently, depression is often associated with an increase in morbidity, mortality, cognitive impairment, suicide, and disability.[9] The peak prevalence of depression is approximately three to six months post stroke but can continue after three years.[2] The underlying mechanism of PSD is not fully understood and may be explained by a biological or psychosocial model.[2] An adaptation of Whyte and Mulsant's[2] evidence of the biological mechanism versus the psychosocial mechanism for PSD is outlined in Table 2 below. There is no evidence to fully support one model or the other. PSD may be a combination of the two, following the biopsychosocial model.

Other consequences of a stroke may be chronic pain and disability. Both greatly affect an individual's quality of sleep, mood, independence, socialization and ability to complete daily activities or rehabilitation.[9,10] All of these factors then dictate a person's health-related quality of life (HRQL). A poor HRQL is associated with comorbidities, mood disorders, and functional

status.[9] There is a clinically significant cyclic relationship between stroke outcomes and HRQL that must be recognized. By breaking the cycle, positive outcomes may be seen in all domains.

Biological Mechanism	Psychosocial Mechanism
A higher depression frequency is seen in stroke compared to other disabilities.[11]	Some studies argue that depression is not more prevalent post-stroke.[14]
Specific ischemic lesions, especially left anterior, are associated with PSD.[12]	The association of lesion and depression may be indirect. Rather the lesion determines disability severity which causes the increased prevalence of depression.[12,15]
Depression is still seen in patients with anosognosia.[13]	Depressive symptoms are typically delayed. This may be a result of social isolation, loss of independence, psychological reaction, or dramatic lifestyle changes.[2]
PSD patients respond to depression treatments differently.[2]	The symptom profile of PSD and other depressions is consistent.[16]
Disruption of neural circuits and neurochemicals.[2]	Poor coping skills[2]

Table 2: *The biological mechanisms versus the psychosocial mechanisms causing post-stroke depression. Adapted from Whyte and Mulsant.*[2,10-16]

Physical activity post-stroke

A sedentary lifestyle has been associated with stroke recurrence, cardiovascular disease, diabetes, reduced mental health, and diminished movement efficiency.[17,18] Stroke is closely associated with lifestyle diseases, meaning that secondary effects of inactivity may exacerbate the already present symptoms of chronic stroke.[19] Research indicates that participating in physical activity after stroke improves pain, disability limitations, overall fitness, and HRQL.[10,20,21] Although post-stroke physical activity has been shown to improve function and mobility, adherence rates continue to remain low.[22] Patients have reported low levels of motivation, poor perceived control, lack of external support and transportation as reasons for not

participating in physical activity.[22] Certain activities, such as yoga, may offer a modified or adaptive means of exercise that facilitates physical activity. Likewise, participation in a group setting or activities that elicit joy may increase external support and motivation. It is important for health care professionals to recognize and consider these limitations when making treatment recommendations.

YOGA

The word "yoga" is derived from the Sanskrit word *yuj* meaning *union*.[23] Many different types of yoga are practiced around the world, but in the west *hatha* is the most common.[18] Yoga therapy is a holistic treatment that incorporates the mind, body, and spirit through a variety of physical postures and breathing exercises.[18,23] The tradition of yoga has 8 elements: *Yama* (morals), *Niyama* (self-discipline), *Pranayama* (breath control), *Asana* (postures), *Pratyahara* (sensory withdrawal), *Dharana* (concentration), *Dhyana* (meditation), and *Samadhi* (blissfulness).[23] These components of yoga unite mindfulness and movement to yield psychological and physical benefits.[23]

Yoga for depression

The connection between increased physical activity and improved mental health has been clearly established.[23] Yoga is beginning to be recognized as an alternative form of exercise and has elicited interest in researchers. The psychological benefits of yoga may include a reduction in depression, anxiety, stress and an increase in self-efficacy.[23] Studies suggest that yoga may be equally effective as pharmacological intervention at treating mood disorders, but without the side effects.[24] The mechanism for this relationship is not completely understood but a few

explanations have been offered. Low levels of Gamma-Aminobutyric Acid (GABA) and a high density of amygdala grey matter are associated with depression and anxiety.[25] Researchers have found an increase in GABA levels from yoga asanas and a reduction of amygdala grey matter from meditation.[26,27] Pranayama breathing practices have also been suggested to down regulate the stress response.[25] A combination of these yoga practices may offer a greater potential for control of emotions and mood.[25]

Yoga for physical function

Physical activity is important in disease prevention and treatment.[28] Yoga, as an alternative form of exercise, may also reduce risk factors of lifestyle diseases. For example, the systematic breathing in yoga reduces the reactivity of the autonomic nervous system (ANS) causing changes in blood pressure, heart rate, and cortisol levels by stimulating the vagal nerve and promoting parasympathetic nervous system (PNS) activation.[23] Other improvements have been seen in blood glucose levels, body composition, and bone density.[28] Reported physical benefits of yoga also include increased flexibility, strength, endurance, and overall fitness.[23] An eight week hatha yoga intervention found that yoga was just as effective in improving functional fitness as stretching and strengthening exercises in the general population.[29] Yoga may even be superior to conventional exercise in the geriatric population by improving balance, thus decreasing the risk of falling.[30]

METHODS

This review includes clinical trials assessing the effectiveness of yoga on adults, post-stroke (age $\geq$ 18). Chapman University's Leatherby Library kinesiology and health science archives were used, including PubMed, Web of Science, Academic OneFile, ScienceDirect, and Google Scholar electronic databases. The initial search terms included: stroke, post-stroke, rehabilitation, yoga, health-related quality of life, disability, depression, and anxiety. Additional papers were identified through the references of the papers in the initial search. All primary studies were considered, with only publications in the English language used. Studies containing pediatric stroke, non-stroke neurological diseases, or subjects with comorbidities were excluded. The initial search yielded 41 articles; 9 of these met the inclusion criteria. A single reviewer assessed the qualifications for inclusion by abstract and then by obtaining the full text.

RESULTS

The selection process produced nine primary studies that evaluated the therapeutic effect of yoga in patients, post-stroke.[18,25,31-36] All participants were adults ranging in age from 24 to 91 years with a mean age of 56. Sample sizes ranged from 3 to 47 participants. Two studies reported higher female participation,[18,33] four reported higher male participation,[31,34-36] and two did not report any gender differences.[25,32] Seven studies conducted a randomized-controlled trial,[18,31-33,35,36] while two used a single-subject study design.[18,34] All studies evaluated chronic stroke with a mean time after stroke of 5.5 years (Van Puymbroeck et al[31] did not include a mean time since stroke). All sample characteristics are summarized in Table 3.

Author	Experimental Design	Sample Size Gender	Mean Sample Age	Mean time since Stroke
Bastille and Gill-Body 2004[18]	Single-subject study	n=4 (1 male, 3 female)	60.0 yrs (49-80)	3.63 yrs
Chan et al 2012[25]	RCT Pilot	n=17	69.4 yrs	8.8 yrs
Garrett et al 2011[32]	RCT	n=22	56.3 yrs (32-85)	9.11 yrs
Immink et al 2014[33]	RCT	n=22 (9 male, 13 female)	59.6 yrs (24-91)	4.38 yrs
Lynton et al 2007[34]	Single-subject Pilot Study	n=3 (2 male, 1 female)	68.7 yrs (63-75)	9.67 yrs
Schmid et al 2012[35]	RCT Pilot	n=47 (38 male, 9 female)	63.1 yrs	4.25 yrs
Schmid et al 2014[36]	RCT	n=47 (38 male, 9 female)	63.1 yrs	4.25 yrs
Van Puymbroeck at el 2012[31]	RCT Pilot	n=47 (76% male)	64 yrs	>6 months

Table 3: *Sample Characteristics of the nine included studies using yoga therapy for chronic stroke.*

Of the nine studies, eight used only yoga as the intervention while one used yoga in conjunction with exercise. The types of yoga include: hatha, satyananda, asana, pranayama, mudra, bandha, and kriyas; not all included the type of practice but described the intervention as "yoga therapy." Most studies used a group class setting taught by a certified yoga instructor, but three used a combination of classes and at home practice.[25,32,33] The length of intervention ranged from 6 to 12 weeks with classes 1-2 times per week for 60 or 90 minutes. The single-subject studies compared the individuals pre and post intervention.[18,34] Of the randomized controlled trials, two used a control group,[31,33] three used a waitlist,[32,35,36] and one compared a yoga plus exercise group to an exercise only group.[25]

The primary outcomes included: balance *(2)*, timed mobility, depression *(2)*, anxiety *(2)*, perceived personal outcomes, motor function *(2)*, QoL *(3)*, aphasia, independence, fear of falling (FoF), self-efficacy, pain, strength, endurance, range of motion (ROM), activity, and participation. A single-subject study found improvement in balance and timed mobility in 50% and 75% of participants respectively,[18] and three RCT reported significant improvements in QoL.[31,33,35] Improvements were also seen in balance, endurance, trait anxiety, independence,

FoF, balance self-efficacy, pain, activity, and participation. Some gains in strength and endurance were noted. No significant differences were seen in depression scores. A summary of study intervention and significant outcomes is outlined in table 4.

Author	Intervention	Intervention Time	Comparison	Primary Outcomes	Significant Outcomes
Bastille and Gill-Body 2004[18]	Yoga (n=4)	8 weeks *(90 min; 2 classes/week)*	Baseline	(1) Balance (2) Timed mobility	(1) Subjects 3 and 4 improved BBS (2) Subjects 1,2,4 improved TMB
Chan et al 2012[25]	Yoga and Exercise (n=9): *hatha, satyananda*	6 weeks *(90 min; 1 class/week, twenty-four 40 min home practices)*	Exercise (n=8)	(1) Depression (2) Anxiety	No significant changes
Garrett et al 2011[32]	Yoga (n=10): *asana, pranayama, mudra, bandha*	10 weeks *(90 min; 1 class/week, 40 min home practice 6 days/week)*	WL (n=12)	(1) Perceived personal outcomes	Improvements reported in body awareness, social interaction, relaxation and stress relief, energy level
Immink et al 2014[33]	Yoga (n=11): *asana, pranayama, satyananda*	10 weeks *(90 min class/week, 40 min home practice/week)*	CG (n=11)	(1) Motor function (2) Anxiety (3) Depression (4) QoL	(1) Endurance (p<0.046) (2) Trait Anxiety (P<0.045) (4) Physical domain (P<0.002), Memory domain (P<0.002)
Lynton et al 2007[34]	Yoga (n=4): *asana, pranayama, kriyas*	12 weeks *(90 min; 2 classes/week)*	Baseline	(1) Aphasia (2) Fine Motor Coordination	Substantial but not significant improvements in dexterity and speech
Schmid et al 2012[35]	Yoga (n=37)	8 weeks *(60 min; 2 classes/week)*	WL (n=10)	(1) Independence (2) FoF (3) Balance (4) Balance self-efficacy (5) QoL	(1) Independence (p<0.001) (2) FoF (p=0.002) (3) Balance (p<0.001) (4) Balance self-efficacy (p=0.035) (5) QoL (p=0.037)
Schmid et al 2014[36]	Yoga (n= 37)	8 weeks *(60 min; 2 classes/week)*	WL (n=10)	(1) Pain (2) Strength (3) Endurance (4) ROM	(1) Pain (p<0.004) (2) Upper extremity strength (p=0.002) (3) Endurance (p=0.010) (4) Neck and hamstring ROM (p<0.001)
Van Puymbroeck et al 2012[31]	Yoga (n=29)	8 weeks *(60 min, 2 classes/week)*	CG (n=9)	(1) Activity (2) Participation (3) QoL	(1) Activity (p=0.02) (2) Participation (p=0.045) (3) QoL (p=0.04)

Table 4: *Intervention type and time, comparison groups, primary outcomes, and significant findings of the nine studies reviewed.*

DISCUSSION

Yoga for PSD

Research has shown the vast benefits of exercise on mental health. In regards to stroke survivors, no cohesive rehabilitation program has been developed to address mental health after stroke. Although the results from this review did not show improvements in depression from a yoga intervention, preliminary data suggests benefits of yoga in complement with exercise.[25] Significant findings in this area for yoga may have been limited by the length of the intervention.

The studies included in this review have shorter program lengths than those previously to have found mental-health benefits.[25] Likewise, PSD following the psychosocial model may be due to decreased QoL from lack of independence, as a result of disability. In that case, improvements in mental health may come secondary to advances in those areas. Therefore, a later evaluation of depression after the intervention may show a greater significance.

Yoga for stroke disability

Many long-term physical impairments may remain after a stroke. Neurological damage often affects motor and sensory coordination associated with balance.[35] A balance deficit can be linked to further disability, decreased physical functioning, and higher rates of falling.[37] Improving balance is a primary concern in stroke rehabilitation but currently there are no standardized balance training recommendations. Looking at an uninjured population, yoga has shown to improve strength and muscle force.[38] In regards to the stroke population, increased muscle force may allow for greater musculoskeletal control leading to better balance and mobility.[18] Similar clinically significant improvements were found by Schmid et al[36] in balance, risk of falling, endurance, strength, ROM, pain, and self-efficacy in post-stroke yoga participants. By improving physical functioning, individuals can become more independent and engage in further physical or social activities.

Yoga for post-stroke HRQL

HRQL should be the foundation for all rehabilitation recommendations. Many interrelated factors are associated with improving HRQL for chronic stroke. Disability is linked to depression and both are tied to independence, self-efficacy, activity, and socialization. Yoga

may offer a multidimensional, comprehensive rehabilitation program that addresses all domains. As previously discussed, yoga has positive effects on physical functioning and mood. By addressing both issues simultaneously, disability and mood disorders will interfere less with life enjoyment eliciting positive, secondary effects on independence, self-efficacy, and activity resulting in an overall improved HRQL.

LIMITATIONS

This review was limited by a number of factors. First, a restricted amount of primary data was available. Few studies have been conducted to evaluate the effectiveness of yoga therapy specifically in the stroke population. Additionally, the existing publications are underpowered due to small sample sizes ($n \leq 47$). The recruitment process can be difficult for this population due to lack of transportation, language impairments, and too great a physical disability. Likewise, the results may have been limited by the intervention length and type. The studies included have an intervention length $\leq$ 12 weeks which may not be long enough to elicit a clinically significant response. Yoga can also be a difficult intervention due to the variety of practices and individuality of the instructors. Yoga instructors use a dynamic and adaptive method of teaching based on the population, personal perspectives, and type of yoga practiced.[23] This makes developing a standardized protocol difficult and should be considered during research design.[23]

CONCLUSION

This review provides preliminary evidence to suggest physical and mental benefits of yoga for chronic stroke. Specifically, yoga may be helpful in treating post-stroke depression and disability resulting in an increased HRQL. Further research needs to be conducted to better characterize the effectiveness of yoga intervention on chronic stroke. It is recommended that future studies develop a more standardized yoga protocol, increase sample size, and increase duration of intervention.

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