A randomized controlled trial of yoga for chronic post-stroke hemiparesis: Motor function, mental health and quality of life outcomes

Running title: Yoga for Stroke

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Reference for published version of this research article:
Immink, M. A., Hillier, S., & Petkov, J. (2014). Randomized controlled trial of yoga for chronic poststroke hemiparesis: motor function, mental health, and quality of life outcomes. ***Topics in Stroke Rehabilitation*****, 21(3), 256-271.**

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ABSTRACT

Purpose: The purpose of the study was to assess the efficacy of yoga for motor function, mental health, and quality of life outcomes in persons with chronic post-stroke hemiparesis. Method: 22 individuals participated in a randomized controlled trial involving assessment of task-orientated function, balance, mobility, depression, anxiety and quality of life domains before and after either a 10-week yoga intervention (n = 11) or no treatment (n = 11). Results: The yoga intervention did not result in any significant improvements in objective motor function measures however there was a significant improvement in quality of life associated with perceived motor function ($p = .0001$) and improvements in perceived recovery approached significance ($p = .072$) . Memory related quality of life scores significantly improved after yoga intervention ($p = .022$) and those participating in the intervention exhibited clinically relevant decreases in state and trait anxiety. Conclusions: Preliminary results offer promise for yoga as an intervention to address mental health and quality of life in persons with stroke related activity limitations. There is a need to more rigorously evaluate these yoga benefits with a larger randomized controlled trial, which, based on this preliminary trial, is feasible.

Abstract word count: 193

Key words: stroke, disability, rehabilitation, mental health, yoga, meditation

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Introduction

Stroke is the second most common cause of adult disability worldwide with estimates that 70% to 88% of ischemic strokes result in long-term motor impairment[1-3]. The most prevalent type of motor impairment in stroke is hemiparesis, involving muscle weaknesses or loss of movement coordination on one side of the body resulting in activity limitations for daily living[4].

In addition to activity limitations, people who have had a stroke have a higher incidence of mood disorders as compared to the general population[5-7]. Some mental health conditions may arise due to the brain lesion associated with the stroke, although the extent of this mechanism is unknown[5,8]. Mood disorders such as depression and anxiety may also be attributable to a lack of coping mechanisms to face the challenge and complexity of life after stroke despite aspirations of recovery and contribution to family and community[9]. Chronic stress and mood disorders have the potential to diminish gait, postural balance and skilled movement[10,11] potentially placing the person with stroke in a vicious cycle of declining quality of life and also further increase the risk of secondary conditions including a repeat stroke or heart disease.

An increase in stroke prevalence coupled with increased stroke survival rates due to improved acute treatment mean that more people will face life with a post-stroke disability and for about the 20% of all people who have had a stroke who are aged 65 or younger, the period of life with a stroke disability can be substantial in length[12,13]. Thus, beyond acute and subacute stages of rehabilitation, there is a critical need to explore options for long-term and sustainable services that allow individuals to engage in practical, active, creative and meaningful ways of addressing life challenges after stroke[9]. This includes services which target both stroke-related motor impairments and mood disorders in order to improve health-related quality of life[14].

Yoga may potentially be an effective solution of managing long-term disability and mental health conditions for persons with post-stroke hemiparesis. The word yoga is derived from the Sanskrit root verb ‘yuj’ which is similar to the English word ‘yoke’, which emphasizes the aim of uniting the mind, body and spirit. In this respect, yoga is a system of personal self-

development that is thought to have originated in Southern Asia and developed over several millennia. One common approach to yoga, called Hatha Yoga, incorporates yoga asana, involving dynamic movement and static body postures, and pranayama, involving awareness of breath and several types of breathing techniques. Frequently, meditation is combined with Hatha Yoga in order to achieve psychological benefits such as promoting stress reduction, emotional stability and mental focus while reducing excessive expectations.

Yoga adopts a holistic view to personal self-development since the establishment and promotion of physical and mental health are viewed as being essential to development of higher states of consciousness, which in turn fosters spiritual development. Initially, yoga was popularized in western societies as a form of spiritual development but then became more popular and accepted as a form of physical activity and fitness development. More recently, yoga has grown in prominence as a form of complementary medicine for self-management of a wide range of chronic conditions. One attractive element of yoga with respect to populations that have activity limitations, such as post-stroke hemiparesis, is that yoga asana practices can be readily adapted to the abilities of the individual. In this way yoga can facilitate physical activity participation in order to promote exercise tolerance and improve other parameters of physical health such as strength, flexibility, mobility and balance in individuals for whom common forms of exercise are not appropriate or desirable. Participation in adapted forms of yoga asana may also offer an opportunity for the individual with hemiparesis to develop movement-related self-efficacy and confidence in order to reduce neglect of the affected side and increase participation in physical activity and activities of daily living.

In addition to promoting physical activity, yoga might also be effective in addressing chronic mental health issues in people with stroke as yoga participation has been shown to reduce symptoms of depression and anxiety in non-stroke populations[15-17]. The mechanisms by which yoga might improve mood disorders have not been delineated but may involve a combination of biological, psychological and social benefits[18]. For example, yoga develops mindfulness[19] and involves physical activity both of which appear to be active components in mental health promotion[20,21]. In addition, anxiolytic effects from practices such as slow deep breathing pranayama might stem from promotion of the parasympathetic division of the autonomic nervous system resulting in lowered heart rate and blood pressure and a more relaxed status[15,22]. The ability to control one's physiological state and consequently mood state, may give a sense of self-mastery and empowerment representing coping strategies to increase personal resilience and positive outlook in life after stroke. Social isolation and

isolation from others facing similar stroke-related challenges might also be alleviated through regular participation in group yoga classes for people who have had a stroke.

There is preliminary evidence supporting yoga as an effective intervention for stroke populations, based on two preliminary single-case studies[23,24] and two pilot randomized controlled trials (RCT)[25,26]. Lynton, Kligler and Shiflett[23] reported improvements in manual dexterity performance on the O'Connor Tweezer Dexterity test following yoga participation in three people post-stroke. Bastille and Gill-Body[24], also using a single case study design, demonstrated improvements in the Timed Movement Battery (TMB) and the Berg Balance Scale (BBS) after the yoga intervention. This study also reported meaningful improvements in self-reported quality based the Stroke Impact Scale (SIS). Chan, Immink and Hillier[25] conducted an RCT study designed to compare mental health outcomes from a yoga and exercise integrated intervention versus an exercise intervention in persons with chronic post-stroke hemiparesis. This comparison did not reveal any significant differences between interventions. However, clinically relevant improvements in symptoms of anxiety and depression were reported for persons receiving yoga and exercise. Schmid et al.[26] conducted an RCT designed to evaluate the benefits of yoga for balance impairment post- stroke. At post-intervention, no group differences between yoga and no treatment control were reported. Still, those who participated in yoga demonstrated a significant improvement in BBS scores and a significant decrease in the percentage of those reporting a fear of falling.

Based on the notion that motor function and mental health may be interrelated[10-12] and the need for interventions that can at the same time address the individual's physical function, mental health and quality of life[14], the present RCT was designed to collectively evaluate motor function, mental health and quality of life outcomes from a post-stroke hemiparesis specific yoga intervention .

Methods

Study Design and Setting

The study was designed as a RCT for community dwelling adults with chronic post-stroke hemiparesis recruited from the Adelaide, South Australia, metropolitan region. It formed part of a comprehensive mixed model quantitative and qualitative approach to evaluate motor function, mental health, and quality of life and also to describe the lived experience of yoga participation from the perspective of a person with chronic stroke hemiparesis. Results of the qualitative component of this study have been reported elsewhere[27].

Participants were randomly assigned to a standardized 10-week yoga intervention group or a wait list control group. Randomization, using concealed allocation procedures, was conducted by a research associate who was external to this study. A random allocation table was generated using Microsoft Excel (Microsoft Corporation, Redmond, WA) to allocate consenting participants to either of the two groups. Participant assessment was conducted by Author 2 who was blinded to participant allocation. The 10-week yoga intervention was conducted in a recreation room at the University of South Australia campus. Participants also completed part of the yoga intervention at their place of residence. The study was approved by the University of South Australia Human Research Ethics Committee and the study was listed with the Australian and New Zealand Registry of Clinical Trials (ACTRN12609000666224).

Participants

For participant recruitment, advertisements were posted in local community newspapers and local television and radio stations announced the study and opportunity for participation. In addition, the study was announced on online listings hosted by state and community health and disability organizations and local health providers were informed of the trial and opportunity for participation.

The inclusion criteria for participation were: being at least 18 years of age, diagnosis of stroke having taken place at least nine months prior to baseline assessment and resulting in hemiparesis (one sided weakness), completion of post-stroke rehabilitation, ability to follow two-step commands and able to ambulate independently or with supervision, with or without an assistive device. The exclusion criteria were: the presence of other neurological or neuromuscular conditions, current or previous participation in yoga or meditation practice or currently participating in structured exercise programs.

Interested individuals were initially screened for participation suitability via telephone conversation with the study investigators. If individuals were deemed suitable for participation, they were invited to be scheduled for a 30-minute baseline assessment in the week that preceded the commencement of the intervention period and they were then randomized for group allocation. At baseline assessment, written informed consent was first obtained followed by recording of participant details and baseline assessment of the trial outcome measures.

Intervention

A standardized 10-week yoga intervention was developed for a chronic post-stroke population with the primary aim of facilitating yoga participation and self-efficacy. The selected practices were appropriate for a beginner level participant and included a range of adaptations and modifications so as to accommodate a range of physical abilities as well as personal needs and preferences. Specific practices were selected for the intervention in order to promote light intensity physical activity, sensory and movement related awareness, active and passive relaxation, and positive mood. These practices included yoga asana and pranayama practices and Satyananda Yoga Nidra® meditation which are described by Swami Satyananda Saraswati[28,29] (see Appendix). Options for adapting yoga practices included, for example: performing bilateral or unilateral versions of yoga asana, performing standing yoga asana practices with balance assistive support and performing yoga practices while seated in a chair. In addition, participants were instructed on the use of mental imagery to replace physical performance of yoga asana in the event that participants felt the asana to be not appropriate or too strenuous for them.

The structure of the 10-week intervention involved weekly 90-minute group classes and daily 40-minute individual home practice. Weekly group classes were facilitated by two accredited yoga instructors with one predominantly providing verbal instructions and the other providing demonstration of relevant practices and also circulating amongst participants to offer individualized support. Each 90-minute group class began with an education component involving a 10-minute lecture on concepts in yoga and the focus theme for that week's class. This was followed by 30 minutes of yoga asana, 10-12 minutes of pranayama and 20-30 minutes of Satyananda Yoga Nidra®. The class concluded with an 8-10 minute discussion where participants were able to ask questions or relate their yoga participation experiences. All of the participants participated in the same weekly group class and attendance at group classes was recorded by the yoga instructors.

The daily home practice represented a shortened version of the group classes. Each home practice session length was between 35-45 minutes with 10-20 minutes for yoga asana and pranayama followed by 25 minutes for Satyananda Yoga Nidra®. Home practice participation was supported by an illustrated guide book and compact disc containing audio recordings to verbally guide the participants through the yoga asana, pranayama and Satyananda Yoga Nidra® practices. Participants maintained a logbook record of home practice participation which was reported to the instructors on a weekly basis. Participants

were encouraged to participate in six days a week of home practice on the days they did not attend the group class.

All participants were advised to maintain their usual treatment and lifestyle behavior where possible during the period of their participation and where necessary, to advise the investigators of any change to these conditions. Participants in the wait list control group did not receive any study related treatment during the 10-week intervention period. Upon completion of assessment at the post-intervention time point, wait-listed participants were offered participation in the 10-week yoga intervention.

Outcome Measures

Motor Function. The present trial included five measures to address motor function outcomes, which were assessed at baseline and post-intervention. The 9-Hole Peg Test (9HPT) was used to evaluate manual dexterity[30]. The Motor Assessment Scale (MAS), a task-orientated approach to assessing functional task performance in stroke, was used to evaluate everyday overall motor function[31]. BBS was used to assess balance[32]. The Two Minute Walk Distance (2MWD) test evaluated the distance the participant was able to ambulate within a timed limit of 2 minutes, with or without an assistive device. This test was chosen as it was a good representation of overall mobility over an extended period of time[33]. The Comfortable Gait Speed (CGS) test was also included as it relies less on endurance due to a short seven-meter test distance and was viewed as a reliable indicator of ambulatory function[34].

Anxiety and Depression. Three mental health outcomes were measured at baseline and post-intervention time points. The Geriatric Depression Scale - Short Form (GDS15) was used as a scale of depression[35]. The two forms of the State Trait Anxiety Inventory (STAI, Form Y) were used to measure state anxiety (STAI-Y1) and trait anxiety (STAI-Y2)[36]. While state and trait anxiety are highly correlated, these were independently assessed in order to separate fluctuating versus longer term changes in anxiety[36].

Quality of Life. The Stroke Impact Scale, Version 3, (SIS)[37] was utilized to measure quality of life across nine dimensions including strength, hand-function, mobility, activities of daily living, emotion, memory, communication, social participation and stroke recovery at baseline and post-intervention. Each dimension was scored with a 100-point scale with a higher score representing higher quality of life. For each participant and each assessment time point, the mean of the strength, hand-function, mobility and activities of daily living scores was

calculated to represent the Physical Domain[37] and this was analyzed along with Emotion, Memory, Communication, Social Participation and Stroke Recovery Domains of the SIS .

Data Analysis

Participant age, gender, affected side and time since stroke characteristics were analyzed descriptively for each group. For the yoga group, compliance to the intervention, in terms of number of weekly group classes attended and number of weekly completed home practice sessions, reported at the beginning of each group class, were also analyzed descriptively.

Participant scores on measures of motor function, mental health and quality of life at baseline and post-intervention time points were analyzed separately using random coefficient regression to examine change between participants receiving the yoga intervention and those receiving no intervention. Random coefficient regression analysis can be used for both normally and non-normally distributed outcomes and allows the analysis to account for the influence of participants on their repeated observations[38]. The regression model treated time as a random factor and included terms for treatment Group, Time and the interaction between these factors, which were of primary interest for this trial. Where a significant Time main effect was found, a paired sample t-test was performed for each group and for any significant changes, the effect size was calculated using Cohen's d. Where a Group*Time interaction reach significance, a Group-wise independent t-test for baseline and post-intervention were performed in addition to the paired sample t-test.

The Intracluster Correlation Coefficient (ICC) was calculated in each analysis. This indicates how much variation is explained by individual subject differences indicated in the regression model, the remaining variation being attributed to pure error. All analyses were performed using SPSS 16.0 (SPSS Inc, Chicago, IL). Only findings with a 2-tailed p value of .05 or less were considered significant, however p values approaching this threshold were reported.

Results

Participants. A total of 41 people responded to recruitment calls for participation and completed a telephone-based interview for the purpose of receiving participation information and completing initial screening (see figure 1). Of these, eight declined participation and another eight individuals were not eligible for participation due to: no presentation of hemiparesis (n = 6), having had a stroke within previous six months (n = 1), and reporting a diagnosis of multiple sclerosis (n = 1). The remaining 25 participants received the participant information sheet and consent form via posted mail, were scheduled for baseline assessment

and were randomized into either the intervention or control group. One participant, allocated to the intervention group, was assessed to not have hemiparesis at baseline and was excluded from participation. Another participant, allocated to the no treatment group, withdrew participation after baseline assessment. Thus, 11 participants commenced and completed the yoga intervention. Of these, two participants inadvertently disclosed their allocation to the yoga intervention at post-intervention assessment. For the no treatment group, 12 participants commenced the wait-list period and 1 withdrew participation prior to post-intervention assessment due to a medical condition unrelated to participation. Data from 11 participants in the intervention group and 11 participants in the control group were included in the analyses.

Insert figure 1 about here

Participants shared similar characteristics in terms of age and affected side however, it appears that the yoga intervention group had a longer mean time since stroke than control group (see table 1). In the yoga intervention group, mean attendance for the 10 weekly group classes was 90% and mean reported completion of the 60 total home practice sessions was 82% representing a mean of 5.2 home practice sessions per week per participant (see table 1). No adverse effects were reported from yoga participation.

Insert table 1 about here

Motor Function. Analysis of 9HPT outcomes was not carried out as planned since 6 participants (54.5%) in the intervention group and 3 participants (27.3%) in the no treatment group could not attempt the baseline test with their affected limb. Analysis of the MAS and BBS outcomes revealed no significant main effects or interactions with a regression model that accounted for 97% and 80% of the variance, respectively. A significant main effect of Time was evident for 2MWD (t = -2.12, p = .046, ICC =.94). Post-hoc analysis revealed no significant change in 2MWD scores for either group. No significant main effects or interactions were evident in the analysis of CGS velocities (ICC = .94). Results for motor function outcomes are presented in table 2.

Insert table 2 about here

Depression and Anxiety. There were no significant effects or interactions for depression scores on the GDS15 (ICC =.52). There were no significant main effects or interactions for

state anxiety (STAI-Y1; ICC = 0.11). A significant main effect of time (t = 2.13, p = .045, ICC = .28) for trait anxiety (STAI-Y2) was obtained. Post-hoc analyses for change in trait anxiety scores for the Yoga group approached significance (p = .078). Results for depression and anxiety outcomes are presented in table 3.

Quality of Life. For the Physical Domain of the SIS, there was a main effect of Time (t = -3.50, p = .002, ICC = .86) and a Group*Time interaction just missed reaching the level of significance (t = 2.05, p = .052). Post-hoc analysis indicated a significant increase in Physical Domain scores (p =.001, Cohen's d =.57) for the Yoga group while the change for the Control group was not significant (p =.663). Analyses of the Memory Domain revealed a significant effect of Time (t = -2.43, p =.024), a Group effect just outside of reaching significance (p =.056) and a significant Group*Time interaction (t = 2.09, p =.048, ICC = .63). Post-hoc analysis indicated a significant increase in Memory Domain scores (p =.022, Cohen's d =.44) for the Yoga group while the change for the Control group was not significant (p =.664). In addition, the Group*Time interaction appears to be based on the Yoga group having significantly higher Memory Domain scores than the Control group at post-intervention (p =.05) while there was no group differences at baseline (p =.793). No significant main effects or interactions were evident for the Emotion, Communication and Social Domains (ICC = .60, .75 and .51, respectively). Results for quality of life outcomes are presented in table 3.

Insert table 3 about here

Discussion

This RCT was designed to assess the effectiveness of yoga participation on motor function, mental health and quality of life clinical outcomes in people with chronic post-stroke hemiparesis. It is the first study to use rigorous methodology to investigate concurrently motor function, mental health and quality of life outcomes from a yoga intervention with a stroke population as previous reports have separately evaluated motor function outcomes[23,24,26] from mental health comes[25]. The sample size of this RCT was small and thus the study was substantially underpowered. Consequently, no definitive statement on the effectiveness of yoga for this population can be made based on the present results. Nevertheless, as a whole, the data appear to support the notion that participation in yoga, in comparison to no intervention, can provide benefits for people with chronic post-stroke hemiparesis.

The motor function outcomes of this trial related to five measures across a range of movement parameters. One of the measures for manual dexterity, the 9HPT, could not be completed by a high proportion of participants in the intervention group and a smaller proportion of participants in the control group. It was therefore omitted from the analysis. Consistent with Lynton et al[23], Bastille and Gill-Body[24] and Schmid et al[26], the present study demonstrated improvements in functional outcomes for mobility and balance. However, these changes did not reach significance in the present trial and similar levels of changes were also apparent in the control comparison group. For example, with the 2MWT measure there was an overall significant increase in distance between baseline and post-intervention. A lack of group differences in balance outcomes was similarly reported by Schmid et al[26]. This raises some question with regard to previous single-case study reports of motor function improvements, which, for example, might be attributable to a repeated testing effect rather than from a yoga participation in of itself. Nevertheless, it would be inappropriate to dismiss previous results at this stage as the present study was underpowered and the present yoga intervention differed to the previous in terms of duration and the type and intensity of yoga practices that were utilized. For example, it may be that the present yoga intervention did not instill an appropriate level of stimulus in order to encourage actual motor function change as the asana involved predominantly beginner level, chair-based gentle movements, which in some cases were performed through mental imagery.

Of particular note is that while the present yoga intervention did not appear to have a clear benefit for motor function outcomes in comparison to people receiving no intervention, there was a significant improvement in perceived motor function on the SIS for participants receiving the yoga intervention. It might be the case that there were improvements related to motor function or recovery of function which yoga participants could perceive in their activities of daily living that were not able to be captured with the present set of motor function measures. For example, participants did report greater strength, flexibility and sensation in the affected side in post-intervention interviews that were analyzed in the qualitative component of this study[27]. Thus, although the present results do not indicate a greater benefit of yoga for motor function in comparison to no intervention, findings from participant's self-perceived improvements in motor function highlight the need to more rigorously and comprehensively assess this clinical research question.

There benefits of the yoga intervention were more reliably aligned with the mental health and quality of life outcomes as compared to motor function outcomes. For example, in

comparison to participants receiving no treatment, there was a trend for participants receiving the yoga intervention to have a larger reduction in trait anxiety. Further, mean state anxiety scores at post-intervention for the yoga group decreased to below the critical score of 39 for a diagnosis of anxiety[39]. Participation in the yoga intervention also resulted in an 8 point decrease in mean trait anxiety scores which has been previously reported as representing a clinically relevant change[40]. In comparison, the control group exhibited just below a 3 point decrease in trait anxiety scores. These clinically relevant improvements in state and trait anxiety scores are consistent with Chan et al[25] who also reported non-significant but clinically relevant improvements in anxiety in a post-stroke chronic hemiparesis group that received an intervention that combined yoga with weekly group exercise sessions. In addition, the present improvements in symptoms of anxiety are consistent with previous reports on the anxiolytic effects of yoga in a general population[17].

In comparison to the clinically relevant improvements in state and trait anxiety, there were smaller decreases in GDS15 scores after participation in the yoga intervention although there was a trend for the yoga intervention to promote larger decreases in depression scores than no treatment. A smaller reduction in symptoms of depression might be due to the fact that at baseline participants as a whole had scores below what would be considered mild depression on the GDS15[41]. Thus, the extent of improvement was possibly limited by a floor effect with respect to symptoms of depression.

The present results do lend further support to the general notion that mental health can benefit from participation in yoga. With respect to populations with chronic post-stroke hemiparesis, these results more specifically provide preliminary support along with Chan et al[25] for a hypothesis that yoga-based interventions provide improvements in mental health. Importantly, mental health benefits may be gained from adapted yoga interventions even in populations with chronic activity limitations stemming from stroke. There remains very little research evaluating mental health benefits of yoga in stroke populations however, there appears to be promise in the potential of yoga in this respect which warrants further investigation. In addition, further investigation into the benefits of yoga for mental health in other populations with motor impairments is warranted.

Although the present study was not designed to establish mechanisms by which yoga might impart improvements in mood disorders, one potential mechanism might involve the relationship between yoga participation and increases in neurotransmitters that support positive mood. For example, Streeter et al[42] have demonstrated increases in γ-aminobutyric

acid (GABA), a neurotransmitter of which low levels have been associated with anxiety disorders[43], following performance of yoga asana. Other mechanisms for lower anxiety following yoga participation might involve improvements in awareness of emotional states, development of behavioral strategies to induce calmer states, such as slow deep breathing, and other coping strategies to face the individual's set of circumstances around stroke-related disability. These mechanisms are consistent with the types of cognitive-behavioral benefits from yoga participation that the participants reported in the qualitative component of this study[27]. However, as discussed below, the present study does have limitations which prevent ruling out other mechanisms such as expected benefits or a placebo effect that may explain mental health improvements from the yoga intervention.

Consistent with Bastille and Gill-Body, there were trends in the data to support the notion that yoga participation can contribute to improved quality of life in individuals with chronic post-stroke hemiparesis[24]. In addition to the Physical Domain, the Memory Domain of the SIS was the other outcome in the study to demonstrate a significantly greater improvement after the yoga intervention. The present improvement in perceived memory function after the yoga intervention, which included a substantial meditation component, is consistent with previous reports of brief meditation training resulting in improved memory function[44] and more generally, that regular meditation practice supports higher cognitive performance levels[45]. In addition, these perceived benefits in memory function are consistent with Subramanya and Telles[46] who reported improved performance on memory tasks immediately following yoga in a non-clinical population. Interestingly, Subramanya and Telles also demonstrated decreases in state anxiety in association with memory performance improvements, which is quite consistent with the present set of results. Yoga may support memory through other mechanisms in addition to reducing negative mood states and this may include improved attention, which in itself is supported by regular participation in meditation[47].

The limitations of the present study beyond its low level of power include the use of convenience sampling as participants likely volunteered based on their interest in yoga and this might have implications for outcomes from participants randomized to the no treatment wait list group. Convenience sampling also limited the extent to which the sample reflected the presence of mood disorders. For example, the yoga intervention group reported low depression scores at baseline which can be argued to not be representative of the prevalence of depression in the stroke population. One question around this is to what extent people with higher levels of post-stroke depression and anxiety would participate in a yoga program

and experience improvement in mental health from yoga participation. A third limitation is that outcomes were only assessed at baseline and post-intervention across a short intervention period. In this respect, one observation was that in the last group class of the yoga intervention, participants appeared to be facing issues associated with loss of opportunity to participate in yoga group classes and were concerned that no such services were available to them in the community. The sense of loss of opportunity to participate in a valuable activity and social opportunity might have carried over into the following week when they were assessed, possibly influencing outcome measures.

Conclusion

The present RCT along with previous quantitative research investigating the efficacy of yoga for people after stroke[23-26] and a qualitative report of the physical, psychological and social benefits of yoga[27] support the rationale for incorporating yoga intervention programs into integrative strategies for reducing the impact of mental health disorders, disability and poor quality of life after stroke, provided individual effectiveness is monitored.

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Acknowledgements

The authors would like to thank the participants for their involvement in this trial. They would also like to thank Ms. Anita Clara and Ms. Lena Lapinska for yoga instruction in the weekly yoga classes. Finally the authors would like to thank the International Yoga Fellowship Movement and Satyananda Yoga® Australia for providing permission for use of yoga practices for the purpose of this trial. This project was funded by the National Stroke Foundation (Australia).

Declaration of Interest

The authors report no declarations of interest.

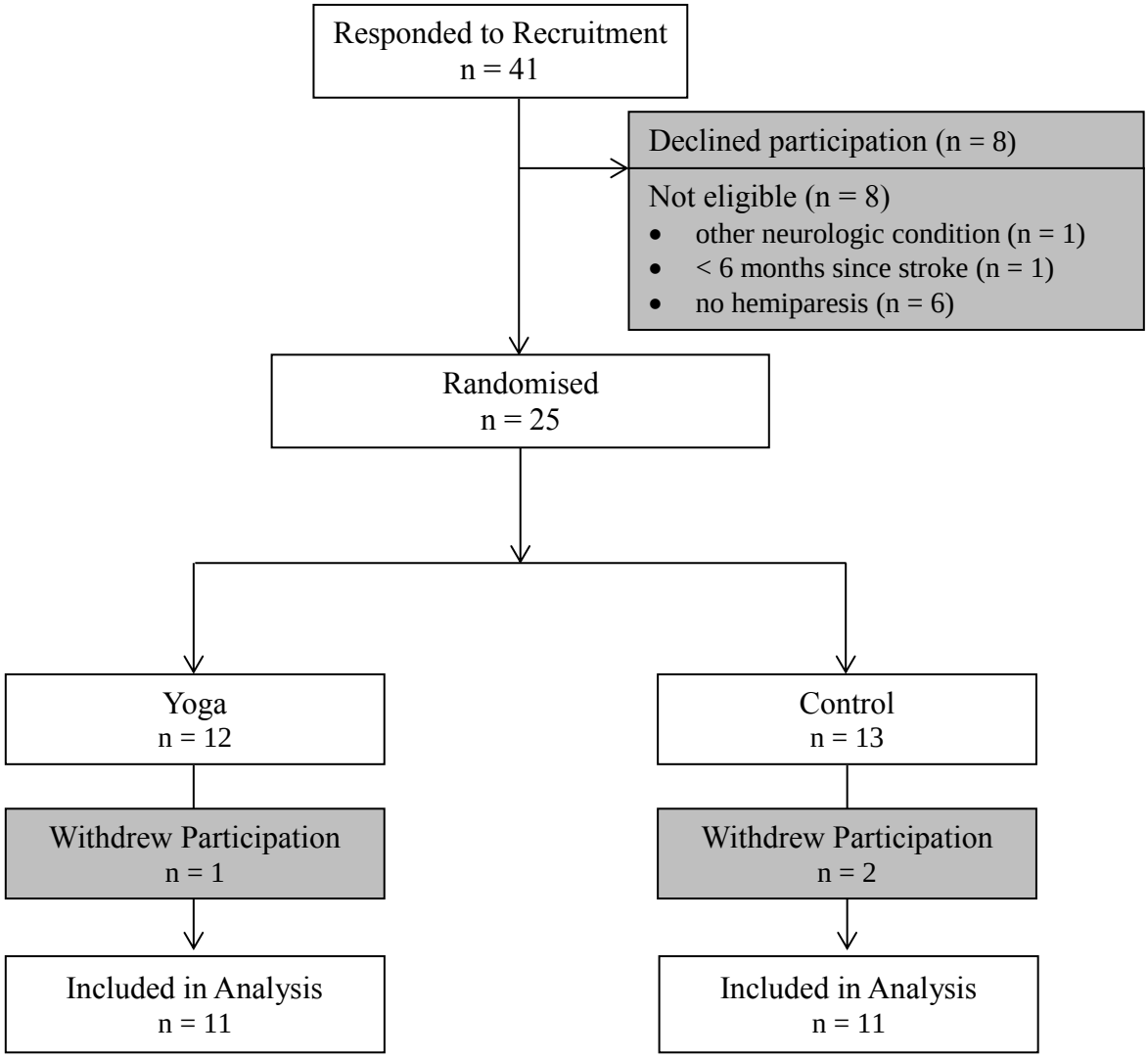

Figure 1. Participant flow diagram.

Table 1. Participant Characteristics and Intervention Adherence

Demographic		Yoga (n = 11)	Control (n = 11)	Overall (n = 22)
Age	Mean (years)	56.1	63.2	59.6
	Standard Deviation	13.6	17.4	15.7
	Range (years)	32-85	24-91	24-91
Gender	Females (n)	5	8	13
Affected Side	Left (n)	10	11	21
Time Since Stroke	Mean (months)	81.6	23.3	52.5
	Standard Deviation	77.5	12.5	61.9
	Range (months)	12-216	9-48	9-216
Intervention Adherence				
Group Class Completion	Mean (%)	90		
	Standard Deviation	12.6		
	Range (%)	60-100		
Home Practice Completion	Mean (%)	82		
	Standard Deviation	20.3		
	Range (%)	40-100		

Table 2. Comparison of motor function outcomes

Measure	Group	Baseline M (SD)	Post-Intervention M (SD)	Change (%)	Main Effect or Interaction, p-value	Post-hoc analysis p-value
Motor Assessment Scale (MAS)	Overall	36.5 (9.7)	37.5 (10.1)	2.6	ns	
	Yoga	34.9 (10.5)	35.5 (10.8)	1.7		
	Control	38.1 (9.0)	39.5 (9.3)	3.7		
Berg Balance Scale (BBS)	Overall	46.2 (12.4)	49.6 (7.1)	7.4	ns	
	Yoga	48.4 (9.1)	50.7 (6.3)	4.8		
	Control	44.1 (15.1)	48.5 (8.0)	10		
2-Minute Walk Distance (2MWD, m)	Overall	89.5 (52.7)	97.1 (49.8)	8.4	Time, $p < .046$	
	Yoga	79.6 (53.0)	90.2 (51.9)	13.3		.142
	Control	99.5 (53.0)	104.0 (49.1)	4.5		.204
Comfortable Gait Speed (CGS, m/s)	Overall	1.9 (4.6)	1.6 (3.3)	-13.5	ns	
	Yoga	2.7 (6.4)	2.2 (4.5)	-18.5		
	Control	.83 (.49)	.88 (.48)	6		

Table 3. Comparison of anxiety, depression and quality of life outcomes

Measure	Group	Baseline M (SD)	Post-Intervention M (SD)	Change (%)	Main Effect or Interaction, p-value	Change Post-hoc Analysis, p-value (Cohen's d)
Anxiety & Depression Outcomes						
Geriatric Depression Scale (GDS15)	Overall	4.9 (3.2)	3.8 (3.2)	-22.4	ns	
	Yoga	3.9 (3.3)	2.7 (2.9)	-30.8		
	Control	5.8 (2.9)	4.8 (3.3)	-17.2		
State Anxiety Inventory (STAI-Y1)	Overall	40.5 (12.2)	37.6 (10.7)	-7.2	ns	
	Yoga	40.7 (13.4)	33.4 (7.1)	-17.9		
	Control	40.4 (11.5)	41.8 (12.2)	3.5		
Trait Anxiety Inventory (STAI-Y2)	Overall	43.6 (10.4)	38.6 (10.7)	-11.5	Time, p < .045	.078
	Yoga	43.0 (12.3)	35.3 (10.5)	-17.9		
	Control	44.2 (8.6)	42.0 (10.2)	-5		.567
Stroke Impact Scale (SIS) Domains						
Physical Domain	Overall	52.3 (20.4)	59.2 (21.8)	13.8	Time, p < .002	**.0001 (.57)**
	Yoga	**53.5 (19.4)**	**64.4 (20.0)**	**20.4**		
	Control	52.3 (19.4)	54.1 (23.3)	3.4		.663
Emotion Domain	Overall	67.2 (16.9)	70.9 (18.2)	5.5	ns	
	Yoga	67.3 (17.0)	74.3 (15.0)	10.1		
	Control	67.2 (17.6)	67.5 (21.2)	0.4		
Memory Domain	Overall	75.4 (20.6)	79.9 (18.1)	6.0	Time, p < .002	**.022 (.44)**
	Yoga	**76.0 (22.3)**	**87.5 (11.0)**	**15.1**		
	Control	74.7 (19.8)	72.2 (21.0)	-3.3		.664
	Group Comparison	p < .793	p < .050		Group*Time, p < .048	
Communication Domain	Overall	88.6 (10.8)	87.3 (12.7)	-1.5	ns	
	Yoga	90.0 (8.1)	88.0 (10.6)	-2.2		
	Control	87.3 (13.1)	86.6 (15.0)	-0.8		
Social Participation Domain	Overall	59.6 (19.9)	62.5 (27.8)	4.9	ns	
	Yoga	60.8 (22.3)	70.6 (24.5)	16.1		
	Control	58.4 (18.1)	54.5 (30.0)	-6.7		
Stroke Recovery Domain	Overall	59.3 (19.6)	64.0 (23.0)	7.9	Time, p < .068	.072
	Yoga	58.2 (17.9)	65.0 (22.6)	11.7		
	Control	60.5 (21.1)	63.0 (24.5)	4.1		.549

Bold indicates statistically significant change.

Appendix. 10-week yoga intervention schedule of practices for weekly group classes and home practice.

A. Weekly Group Classes

	Week									
	1	2	3	4	5	6	7	8	9	10
Focus Theme	Introduction to Yoga	Introduction to Yoga	Connecting with Body Sensations	Connecting with the Breath	Breath and Movement Coordination	Breath and Movement Coordination	Internalising	Visualising	Deepening Body and Breath Awareness	Stillness
Asana										
Prarambhik Sthiti (sitting posture)	■	■	■	■	■	■	■	■	■	■
Savasana (corpse pose)								■	■	■
Padanguli Naman (toe bending)			■			■	■	■	■	■
Goolf Chakra (ankle rotation)	■	■	■	■	■	■	■	■	■	■
Janu Naman (knee bending)	■	■	■							
Mushtika Bandhana (hand clenching)	■	■	■	■	■	■	■	■	■	■
Manibandha Naman (wrist bending)				■	■	■	■	■	■	■
Kehuni Naman (elbow bending)	■	■			■	■	■	■	■	■
Skandha Chakra (shoulder rotation)			■	■						
Greeva Sanchalana (neck movements)	■	■	■	■	■	■	■	■	■	■
Pada Sanchalanasana (leg cycling)						■	■	■	■	
Nauka Sanchalanasana (rowing the boat)								■	■	■
Rajju Karshanasana (pulling the rope)					■	■	■		■	
Majariasana (seated cat stretch pose)							■	■	■	■
Tadasana (palm tree pose)	■	■	■	■	■	■	■	■		■
Tiryaka Tadasana (swaying palm pose)					■	■		■		■
Kati Chakrasana (waist rotating pose)			■	■		■		■		■
Utthanasana (squat and rise pose)				■	■					■
Eka Pada Pranamasana (standing prayer pose)									■	■
Pranayama										
Natural breath awareness	■	■	■	■	■	■	■	■	■	■
Abdominal breath	■	■	■	■	■	■	■	■	■	■
Thoracic breath				■	■	■	■	■	■	■
Full Yogic Breath					■	■	■	■	■	■
Mental Nadi Shodhana						■	■	■	■	■
Meditation										
Satyananda Yoga Nidra®	■	■	■	■	■	■	■	■	■	■

B. Daily Home Practice

	Weeks	
	1-5	6-10
Asana		
Prarambhik Sthiti (sitting posture)	■	■
Goolf Chakra (ankle rotation)	■	■
Janu Naman (knee bending)	■	
Manibandha Naman (wrist bending)	■	
Skandha Chakra (shoulder rotation)	■	
Nauka Sanchalanasana (rowing the boat)		■
Tadasana (palm tree pose)	■	■
Tiryaka Tadasana (swaying palm pose)		■
Kati Chakrasana (waist rotating pose)	■	■
Utthanasana (squat and rise pose)		■
Pranayama		
Natural breath awareness	■	
Abdominal breath	■	■
Mental Nadi Shodhana		■
Meditation		
Satyananda Yoga Nidra®	■	■

Note: Asana practices described in Asana Pranayama Mudra Bandha[28] were adapted for individuals with no prior yoga experience and with hemiparesis. Participants were provided with options to complete practices including unilateral movement, sitting for standing or floor-based practices and mental practice of the movement.