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Methods: Sedentary community dwelling older adults (N=118, Mage=62.02) were randomized to an 8-week yoga intervention or a stretching control group. At baseline and following 8 weeks, all participants completed measures of cognition, self-reported stress and anxiety and provided saliva samples before and after cognitive testing to assess cortisol.
Results: Yoga participants showed improved cognitive scores and an attenuated cortisol response compared to their stretching counterparts who showed increased cortisol levels and poor cognitive performance at follow up. The change in cortisol levels as well as self-reported stress and anxiety levels predicted performance on the running span task, n-back working memory and task switching paradigm (β's=.27 to .38, p's $\leq$.05 for yoga and β's=-.37 to -.47, p's $\leq$.01 for stretching control).
Conclusion: Eight weeks of regular yoga practice resulted in improved working memory performance that was mediated by an attenuated response to stress as measured by self-report stress and objective salivary cortisol measurements. This trial offers evidence for non-traditional physical activity interventions such as yoga that may be helpful in restoring HPA balance in older adults, thereby preventing cognitive decline.

Yoga Practice Improves Cognition by Attenuating Stress Levels

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Introduction

Mind-body interventions such as yoga are promising approaches for improving cognitive function in older adults. In a recent meta-analysis of the yoga-cognition literature, Gothe & McAuley[1] found that both, acute (short bouts) and chronic (long term, interventions) practice of yoga was associated with improvements in cognition, including the domains of executive function (g=.27), attention and processing speed (g=.29) and memory (g=.18). In spite of the growing interest and evidence for the cognitive effects of yoga, there have been no systematic investigations of potential mechanisms that may underlie this relationship.

Preliminary evidence suggests that yoga has a down regulating effect on both the sympathetic nervous system (SNS) and the hypothalamic-pituitary adrenal (HPA) axis in response to stress[2]. Stress, in general, may lead to anxiety and depression, involving chronic sympathetic activation and activation of HPA[3]. Prolonged activation of this system is thought to have deleterious effects on brain function. In a recent review, Lupien and colleagues[4] concluded that chronic exposure to stress hormones, whether it occurs during the prenatal period, infancy, childhood, adolescence, adulthood or aging, has an impact on brain structures involved in cognition and mental health.

Yoga has been shown to have immediate psychological effects including decreased anxiety[5], depression[6], stress[7], and improved QOL and well-being[8]. Cortisol, a stress hormone and an end-product of the HPA axis has been assessed in some yoga studies and lower cortisol levels have been associated with improved affect[9–11]. These studies suggest that yoga has an immediate quieting effect on the SNS/HPA axis response to stress. La Forge[12] suggested that at least part of the power of yoga's effects is its ability to help participants cultivate better stress management skills. While the precise mechanism of action has not been determined, it has been hypothesized that some yoga exercises cause a shift toward parasympathetic nervous system dominance[13], which may impact cognitive performance.

Salivary cortisol is an excellent indicator of plasma-free cortisol, increasingly used to assess hypothalamic–pituitary–adrenal axis secretory activity and rhythm[14,15]. A randomized controlled trial (RCT) comparing African dance and Hatha yoga showed that cortisol levels decreased after the Hatha yoga session in healthy college students and the changes in positive affect and change in cortisol were negatively correlated[9]. Kamei and colleagues[10] also reported similar reduction in serum cortisol after a 50 minute yoga session in a sample of 8 yoga instructors. A 3-month Iyengar yoga program for middle aged women also showed decreased salivary cortisol and improvements in stress, anxiety and well-being[16]. Similar results were observed in a 6-week RCT with breast cancer outpatients[17]. Decreased anxiety, stress, depression and salivary cortisol were reported by the yoga group patients as compared to the usual care controls. Other analogous mind-body techniques, including mindfulness based stress reduction[18], transcendental meditation[19] and tai-chi[20] have been shown to elicit a similar relaxation response along the SNS and HPA axis activity. Anxiety remains a critical moderator within the field of cognition because it is associated with adverse effects on two central executive functions involving attentional control: inhibition and set shifting[21]. It is plausible that changes in stress-related physiological systems and affect may be among the mechanisms that lead to improved cognitive performance following yoga practice.

In a previously published manuscript we reported the beneficial effects of this 8-week Hatha yoga intervention on executive functions – specifically the domains of working memory and task switching among sedentary, but healthy older adults[22]. In light of these primary outcomes and the literature suggesting changes in the SNS and HPA axis activity, herein we systematically investigate cortisol and self-reported stress and anxiety as potential mediators of the yoga-cognition relationship. We hypothesized that changes in salivary cortisol and affective states would predict improvements in cognitive performance following the 8-week yoga intervention.

Methods

Participants

Figure 1 shows the flow of participants through the trial. Detailed recruitment, screening and trial procedures have been previously reported[22,23]. Briefly, participants (N = 118, males = 26; mean age = 62.0 ± 5.6) were low active, healthy community dwelling older adults who volunteered to participate in an 8-week exercise based RCT. They were recruited between March 2012 and January 2013 through University of Illinois list serves, fliers, community groups and postings and screened to determine eligibility for the study. In order to participate in the trial, participants had to be between 55-79 years of age, English speaking, report being sedentary for at least the previous six months (<2 days per week of structured physical activity), have no on-going regular yoga practice, be able to get up and down from the floor, have good or corrected vision (20/40), and be willing to be randomized into one of two exercise groups. Since the primary outcomes included neurocognitive variables, all participants were screened to rule out possible cognitive deficiency using the modified Telephone Inventory for Cognitive Screening[24] with a cut-off of 21, and for depressive symptomology using the shortened version of the Geriatric Depression Scale[25] which has a cut-off point of ≥ 5. Individuals who responded to advertisements completed a telephonic prescreening interview to determine whether they met these inclusion criteria and consented to have their physician be contacted for approval to participate in the exercise study. Individuals were excluded from participation if they did not meet the above criteria or their physician refused to provide approval for participation.

Procedures

After obtaining the physician's consent, participants were scheduled to complete baseline cognitive assessments and provided with a questionnaire to collect basic demographic information. After all baseline data were obtained, participants were stratified by age and sex and randomized into one of two groups: Hatha yoga or stretching-strengthening exercise. For both groups, classes met 3 times a week for an hour over the 8-week period. Different instructors led the two arms of the trial; yoga was supervised by certified yoga instructors and the stretching-strengthening sessions were led by certified fitness trainers. The instructors in both groups monitored participants' attendance over the course of the 8-week program.

Hatha yoga group: The yoga intervention was designed as a beginner but progressive 8-week program involving supervised group sessions led by certified yoga instructors. Within the 3 sessions each week, new postures, breathing and meditative exercises were introduced on Mondays, Wednesday's class helped to further develop concepts while reviewing and adding some new postures. Friday's class was dedicated to reviewing the week's material to ensure the yoga practice was smooth and progression was gradual and steady through the 8-week intervention. Yoga practice was done barefoot and participants used yoga mats, yoga blocks and belts during the sessions. Some of the yoga exercises practiced by the participants included: warrior pose, easy lotus pose, sun salutations, deep breathing exercises such as alternate nostril breathing, and meditative exercises focusing on thoughts, breath and mantra repetitions.

Stretching and strengthening control group: This group served as an active exercise control group to the yoga intervention for the period of 8-weeks. Participants received the same level of interaction with the research staff and same opportunities for social interaction with others in their group and the certified trainer as the Hatha yoga group. No Hatha yoga postures, breathing and meditative exercises were practiced by this group ensuring that it served as a true attentional exercise control to the yoga intervention. Participants in this group also met on the same days and times at a separate exercise studio, to engage in stretching and strengthening exercises that met the Center for Disease Control (CDC) anaerobic recommendation[26]. Each class consisted of a warm up and a cool down and the participants completed 10-12 repetitions of 8-10 different exercises led by a certified personal trainer. Similar to the yoga intervention, the exercises were progressive over the course of 8-weeks and resistance bands, blocks and chairs were used to perform the exercises which included bicep curls, tricep extensions, flutter kicks seated in the chair etc. These exercises targeted all major muscle groups but did not involve any yoga based postures, breathing or meditative elements.

Measures

Demographic and participant information

Participants completed a basic demographic questionnaire including age and date of birth, sex, marital status, occupation, income, education and past experience with yoga.

Salivary Cortisol

An extensive meta-analysis[27] suggests that significant cortisol responses were elicited by cognitive tasks (d=.20), effects were significantly greater for assessments obtained in the afternoon (d=.46) and 21-40 minutes after the onset of the stressor (d=.38-.41). Capitalizing on these findings, in the present study, two saliva samples were collected at each time-point during the cognitive testing appointments that were held in the afternoon. The cognitive assessments were used as psychological stressors to elicit a stress response, and saliva samples before beginning the session (pre-stressor) and 40 minutes into the session (post-stressor) were collected from the participants. This response to stressor (pre-stressor cortisol levels/post-stressor cortisol levels) at follow-up was used as a predictor for analyses. The passive drool procedure was employed which involved allowing the subject to pool saliva in his/her mouth (~1.5ml) and then send it through a short straw into a vial. Because cortisol production has a circadian rhythm[15,28] the pre and post cognitive assessments and saliva sample collection were conducted at the same time of the day (2:00 pm pre-stressor and 2:40 pm post-stressor) for all participants at both time-points. Samples were stored at -80° C upon collection. A high sensitivity cortisol enzyme immunoassay kit (Catalog No: 1-3002 (5PK 1-3002-5), Salimetrics Inc., State College, PA) was used to assess cortisol levels in the saliva samples. All saliva samples for a participant were assayed together, as per the kit manufacturer's instructions, in duplicates by a blinded analyst (RK). The end-point absorbance for the assay was measured at 450nm on a Synergy-2 plate reader (Biotek, Winooski, VT). The detection range for the assay was 0.012-3.000 µg/dL. Samples exceeding 3.0 µg/dL (very high cortisol concentrations), were re-analyzed in duplicates after dilution (10x). A 4-parameter sigmoid minus curve fit was examined for each plate based on the standards and controls (R^2 range: .999 to 1). The intra- and inter-assay coefficients of variation (CVs) were < 15% as recommended by the manufacturer.

Self-reported Stress and Anxiety

Participants completed the following self-reported measures during the pre- and post- cognitive testing sessions immediately following the saliva sample collection.

Perceived Stress Scale. Perceived Stress was measured using the 14-item Perceived Stress Scale[29]. Each item is rated on a 5 point scale from never (0) to very often (4). The scale has showed adequate reliability and is designed to measure the degree to which situations in one's life are appraised as stressful. The scale score is computed by aggregating the item scores with higher scores indicating greater stress.

State Trait Anxiety Inventory. The State Trait Anxiety Inventory[30] is a 40 item instrument divided into two sections. The first subscale measures state anxiety - anxiety about an event, and the second measures trait anxiety - a stable tendency to respond with anxiety. The state subscale was used at the cognitive testing sessions. Items are scored on a four point likert scale (1=not at all to 4=very much so) resulting in a range of scores from 20-80 for each subscale. Higher scores are indicative of greater anxiety.

Cognitive Assessments

At baseline and following the 8-week intervention, all participants completed the same neuropsychological test battery. We employed three established computer based tests using E-prime 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA) to assess the executive functions of working memory and task switching. The cognitive assessments employed in this study have been described in detail previously[22] and are briefly reported in this manuscript.

Working Memory Measures. Two measures of working memory capacity, the running memory span and n-back task were used. The letter version of the running memory span test[31] involved reporting the last n letters (n= 3, 4, 5 or 6) from a string of $m+n$ letters presented one at a time, on a computer screen. Following the sequential presentation, participants made their recall responses by clicking the cells of a 3x4 grid displaying all letters from the set of possible letters. Partial recall score was calculated for trials when $m>0$ and total recall score presented performance on trials where $m=0$.

In addition to the running span task, a modified serial n-back task [32,33] was administered which involved two consecutive phases: 1-back, and 2-back. Each phase required the participants to discriminate between sequences of letters that served as stimuli. In the 1-back condition, the participant was instructed to respond as quickly and accurately as possible if the current letter was the same as the previous trial for the 1-back condition, and two trials previous for the 2-back condition. Accuracy on the 1 and 2 back conditions was examined.

Task Switching Measure. The odd or even, low or high version of the task switching paradigm was used in this study[34 35]. Participants were asked to switch between judging whether a number was odd or even and judging whether it was low or high (i.e., smaller or larger than 5). The task consisted of single block of trials (either rule) and a mixed block (both rules). Accuracy on single and mixed blocks as well as repeat (trials when the preceding trial involved the same task, e.g. blue followed by blue) and switch trials (when the preceding trial was of the other task, e.g. blue followed by pink) was examined.

Data Analysis

Data were analyzed using SPSS 20.0 (IBM Corp., Armonk, NY). Prior to all hypotheses testing, independent sample *t*-tests were conducted to examine whether significant mean differences existed in demographic, cognitive, cortisol and self-reported stress and anxiety variables between the two groups at baseline. Analysis of covariance models were employed to determine group differences at follow-up for the study variables. Change scores were then calculated for each of the cognitive variables (e.g. accuracy at follow up – accuracy at baseline). In an attempt to explore the predictors of the yoga-cognition relationship, multiple linear regression analyses by group were conducted to determine whether change in the salivary cortisol level, anxiety and stress scores (controlling for age and sex) predicted improvements in each of the executive function measures.

Results

Table 1 shows the participant characteristics by group. Within both groups, the majority of the participants were female, married, working full time, well-educated and relatively affluent. Approximately 20% of the study participants represented minority groups. An independent samples t-test showed no significant differences between conditions on any of these characteristics (all p's $\geq .20$).

The means and standard deviations of the variables measuring anxiety, stress and salivary cortisol are presented in Table 2. Again, no baseline differences were observed between the two groups (all p's $\geq .15$). Salivary Cortisol were measured in µg/dl and were in the range of 0.1-2 µg/dl as expected for normal healthy subjects[36] except for 3 samples which were diluted 10X for measurement. A distribution of cortisol data showed 8 outliers (n=5 for yoga, n=3 for control) that were more than 3 standard deviations from the mean levels at least one time-point including follow-up. Two of the 8 participants had reported life events (death in the family, laid off at work) to the research staff during the course of the trial, however no record was documented for the remaining 6 participants who exhibited extremely high cortisol levels. These data points were dropped from further analyses to avoid situational bias, resulting in a sample size of 100 at follow up for cortisol analyses.

Group differences at follow-up

At follow-up, the ANCOVA reported a significant group difference for post-stressor cortisol levels [$F(1,97)=4.55$, $p=.04$, partial $\eta^2=.05$] where the yoga group showed lower values than the stretching control (.15 µg/dL Vs. .18 µg/dL respectively). No significant group differences were observed on the self-report stress and anxiety scales at follow up. However, significant time effects were observed for both perceived stress [$F(1,106)=11.58$, $p=.001$, partial $\eta^2=.10$] and state anxiety scores [$F(1,106)=9.05$, $p=.003$, partial $\eta^2=.08$]. The time effects were in the expected direction with both groups reporting lowered self-reported stress and anxiety after 8-weeks of exercise.

Mediators of the yoga-cognition relationship

Results from the multiple regression analyses conducted for each of the cognitive measures are presented in Tables 3 and 4. Multiple regression analysis on the running span scores indicated that post-stressor change in salivary cortisol predicted change in the total recall scores (β=.38, p=.01) and the partial recall score (β=.30, p=.04) for the yoga group. The result was in the expected direction such that an attenuated cortisol response to the stressor (i.e. cognitive tasks) predicted improved total and partial recall scores on the running span task. On the n-back task, reduced state anxiety predicted improved accuracy on the 1-back (β=.27, p=.04) for the yoga group, whereas increase in salivary cortisol was predictive of poor performance on the more cognitively demanding 2-back (β= -.37, p=.01) for the stretching strengthening group. On the task switching outcomes increased salivary cortisol consistently predicted poor accuracy on the mixed (β=-.46, p=.002), repeat (β=-43, p=.004) and switch (β=-.47, p=.002) trials for the stretching and strengthening group.

Discussion

To our knowledge this is the first study to systematically examine cortisol and self-reported affect as mediators of the yoga-cognition relationship. The exploratory hypothesis of changes in salivary cortisol, anxiety and stress predicting cognitive performance was only partially supported in this study. Although the yoga group showed an attenuated stress response to the cognitive tasks (stressor), these change scores predicted performance on the accuracy of working memory measures administered in this RCT. The control group on the other hand showed an elevated cortisol response that predicted poor performance on the task switching outcomes. Overall, the regression results indicated that cortisol was predictive of working memory performance and mental flexibility. However, the perceived stress and state anxiety scores showed no associations with cognitive measures. These null findings can be explained by the short duration of the study and the fact that all participants were both physically and mentally healthy and high functioning. They indicated ‘feeling good’ and ‘more relaxed’ on the informal program feedbacks, however, the self-report measures may not have captured these subjective perceptions effectively given the short duration of the intervention.

The current study demonstrated small effect sizes as per Cohen’s classification of the magnitude of the effect size [37]. The standardized beta values ranged from .27 to .38 and these small effect size maybe in part due to our sample of normal and healthy subjects in the trial. Although the predictors did not consistently account for variance in the cognitive performance measures, the changes in cortisol following yoga practice and improving executive functions are important findings. Stress and anxiety may be particularly critical in affecting information processing. The ability to self-regulate emotions has been found to be a key component in enhancing cognition[38]. It is possible that the calming effects of yoga combined with the increased capacity to focus on the present improved cognitive performance after 8-weeks of regular practice. Yoga enhances present moment awareness by teaching participants to notice subtle distractions (feelings; thoughts) while repeatedly bringing attention back to the meditation object such as one’s breath or specific parts of the body. This process can promote attentional stability.

Mean level changes in cortisol following a yoga intervention have been previously reported[9,10,16,17,39] where yoga practice has shown improved stress levels by restoring the body’s sympathetic-parasympathetic balance. Research has also shown that prolonged activation of the HPA system has deleterious effects on brain function[40,41] and neuroendocrine studies suggest that brain exposure to higher cortisol concentrations contribute to cognitive deficits as we age[42,43]. Larger RCTs assessing a broader spectrum of cognitive functions and comprehensive cortisol assessment protocols will enable us to reliably determine if yoga interventions moderate the deficits and improve cognitive performance by acting upon the HPA system. Future research also needs to examine other biomarkers and physiological or molecular changes that may underlie the yoga-cognition relationship.

Other than the mechanisms explored in this study, there are a number of possible processes that may explain the relationship between yoga and cognitive improvement. In the physical activity-cognition literature, experiencing novel activities[44] and anaerobic interventions have been shown to have unique cognitive benefits on brain structure and function[45]. From this neuroscientific perspective, tasks that involve mind wandering, memory consolidation, thought focused inwards often referred to as self-referential thinking, and taking the perspective of others into one's own view of the world have been associated with the default mode network. This is a network of brain regions that are active when the individual is at rest but not focused on the outside world[46,47]. There is evidence that supports a relationship between the default mode network and executive function, where increased default mode network function has been associated with better working memory performance in young adults[48], and better performance on a range of executive function tasks in older adults[45,49–51]. At the same time there is emerging evidence for the role of stress in the functional connectivity of the brain and its default mode network function [52]. Awareness-based behavioral interventions such as mindfulness have shown to moderate the neural-cortisol association [53]. The holistic practice of yoga in this study was largely awareness-based and a self-referential mind-body practice which appears to have modulated the stress response and in turn, improved cognitive performance on the executive function measures for the yoga participants.

Although this study contributes greatly to the sparse yoga-cognition literature, it does have some limitations. Although the salivary cortisol analyses were blinded, the assessment protocol used in this trial could be refined in future work. Taking into account the duration of the study and participant burden to complete assessments, saliva samples were collected only once at each time-point in the present study. Collecting multiple saliva samples at each timepoint and at various times of the day to account for the circadian rhythm of cortisol may serve as more reliable markers. The perceived stress scale did not accurately capture situational stressors such as being laid off at work or death in the family. Such life events should be formally recorded in the future, to more accurately and reliably account for outliers in the data sets. Questions about the optimal dose of yoga to modulate stress and gain cognitive benefits cannot be determined in this trial. Finally, the lack of a follow-up timepoint limits us from determining the maintainence of cognitive benefits after the cessation of the intervention.

A closer examination of possible predictors indicated that the HPA axis might play a role in inducing cognitive changes, however the exact neurobiological changes within the brain remain unknown. Other biomarkers including neurotransmitters and growth factors need to be inverstigated. The physical activity and cognition literature has adopted advanced neuroimaging techniques to examine structural and functional changes that occur as a result of exercise and it remains to be seen how yoga compares to those findings. Future studies should replicate these outcomes across different age groups, among clinical populations and examine the dose-response relationship of varied durations and frequencies of yoga practice.

Figure 1. Flow of participants through the study

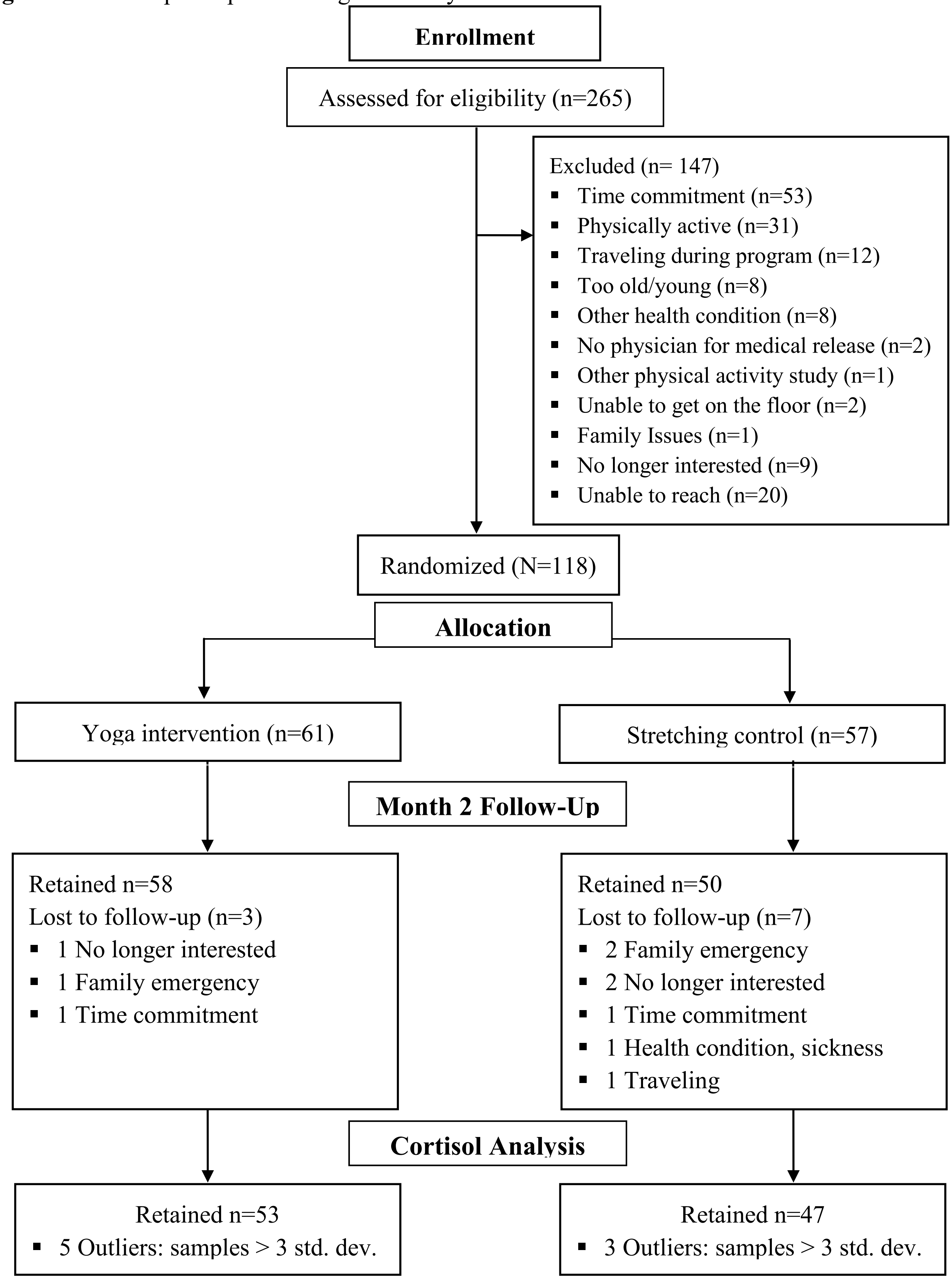

Table 1. Demographic characteristics of participants at baseline

	Yoga n=61	Control n=57
Age (mean, sd)	62.1 (±5.82)	62.0 (±5.39)
Sex (n, %)		
Females	49 (80.3%)	43 (75.4%)
Males	12 (19.7%)	14 (24.6%)
Race (n, %)		
African American	7 (11.5%)	4 (7.0%)
Asian	2 (3.3%)	2 (3.5%)
American Indian/Alaskan Native	0 (0%)	2 (3.5%)
More than one race	1 (1.6%)	3 (5.3%)
Caucasian	51 (83.6%)	46 (80.7%)
Education (n, %)		
< College degree	14 (23%)	25 (43.8%)
> College degree	47 (77%)	32 (56.2%)
Income (n, %)		
< 40,000	11 (17.9%)	16 (28.2%)
> 40,000	50 (82.1%)	41 (71.8%)
Marital status (n, %)		
Married	34 (55.7%)	39 (68.4%)
Separated/Divorced	15 (24.6%)	11 (19.3%)
Widowed	7 (11.5%)	4 (7%)
Single	3 (4.9%)	2 (3.5%)
Partnered/Significant other	2 (3.3%)	1 (1.8%)
Employment status (n, %)		
Retired	13 (21.3%)	13 (22.8%)
Working part time	15 (24.6%)	13 (22.8%)
Working full time	32 (52.5%)	30 (52.6%)
Unemployed	1 (1.6%)	1 (1.8%)
Yoga experience (n, %)		
Had tried it in the past	18 (29.5%)	20 (35.1%)
Would probably try it	43 (70.5%)	37 (64.9%)

Note: No significant group differences observed at baseline, all p's ≥ .19

Table 2: Means and standard deviations at baseline and follow up for salivary cortisol, anxiety, stress and executive function variables

	Yoga		Control		ANCOVA
	Pre	Post	Pre	Post	*p* value*
Salivary cortisol (μg/dl)					
Pre-stressor	.15 ± .07	.18 ± .06	.16 ± .09	.16 ± .06	.11
Post-stressor	.16 ± .10	.15 ± .07	.17 ± .10	.18 ± .08	.04
State Anxiety	33.10 ± 9.3	30.71 ± 9.7	32.77 ± 8.9	30.80 ± 9.7	.98
Perceived Stress	12.11 ± 6.4	10.67 ± 5.6	13.95 ± 7.2	12.18 ± 6.4	.77
Running Span					
Partial recall	15.61 ± 6.86	17.97 ± 6.68	16.89 ± 5.85	16.76 ± 6.81	.01
Total recall	29.48 ± 8.93	31.64 ± 8.71	29.3 ± 8.32	29.68 ± 9.24	.11
N-Back					
1back accuracy	0.97 ± .05	0.98 ± .03	0.96 ± .05	0.97 ± .06	.18
2back accuracy	0.8 ± .18	0.87 ± .11	0.84 ± .13	0.82 ± .17	.003
Task Switching					
Single accuracy	0.94 ± .10	0.98 ± .05	0.92 ± .09	0.94 ± .11	.02
Mixed accuracy	0.87 ± .16	0.94 ± .08	0.84 ± .22	0.88 ± .21	.09
Repeat accuracy	0.89 ± .14	0.95 ± .07	0.86 ± .22	0.88 ± .21	.10
Switch accuracy	0.85± .18	0.93 ± .09	0.83 ± .23	0.87 ± .21	.15

Note: *ANCOVAs examining group differences post intervention, controlling for age, sex and baseline scores

Table 3: Multiple regression results with predictors for the working memory change scores

Measures / **Predictors**	Running Span - partial score			Running Span – total score			N-back – 1back accuracy			N-back – 2back accuracy		
Yoga Group												
	β	t	*p*	β	t	*p*	β	t	*p*	β	t	*p*
Salivary Cortisol	.30	2.08	.04	.38	2.63	.01	-.23	-1.60	.11	.05	.35	.73
State Anxiety	.12	.85	.40	-.02	-.16	.87	.27	2.07	.04	.03	.21	.83
Perceived Stress	.06	.43	.67	.07	.46	.65	-.11	-.80	.43	-.19	-1.30	.20
Stretching Group												
	β	t	*p*	β	t	*p*	β	t	*p*	β	t	*p*
Salivary Cortisol	-.10	-.62	.54	.06	.41	.69	.02	.16	.88	-.37	-2.67	.01
State Anxiety	-.15	-.91	.37	-.14	-.85	.40	.12	.69	.49	-.04	-.25	.80
Perceived Stress	-.10	-.64	.53	-.08	-.47	.64	.08	.47	.64	.25	1.75	.09

Table 4: Multiple regression results with predictors for the task switching change scores

	Yoga Group											
Measures / **Predictors**	Single Trials Accuracy			Mixed Trials Accuracy			Repeat Trials Accuracy			Switch Trials Accuracy		
	β	t	*p*	β	t	*p*	β	t	*p*	β	t	*p*
Salivary Cortisol	-.12	-.83	.41	.07	.47	.64	.07	.46	.65	.08	.48	.63
State Anxiety	.03	.18	.86	.03	.17	.86	-.02	-.11	.91	.05	.35	.73
Perceived Stress	-.29	-1.99	.05	-.06	-.38	.70	-.06	-.40	.69	-.04	-.25	.80
	Stretching Group											
	β	t	*p*	β	t	*p*	β	t	*p*	β	t	*p*
Salivary Cortisol	-.25	-1.63	.11	-.46	-3.24	.002	-.43	-3.29	.002	-.50	-3.46	.001
State Anxiety	-.10	-.63	.53	.19	1.28	.21	.25	1.65	.12	.13	.83	.41
Perceived Stress	-.22	-1.39	.17	-.07	-.50	.62	-.08	-.53	.53	-.08	-.51	.61

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***Highlights (for review)**

Highlights

- An 8-week Hatha yoga intervention attenuated stress response in an older adult sample.
- The change in salivary cortisol predicted cognitive performance.
- Novel and preliminary evidence for the role of HPA axis in the yoga-cognition relationship.