Yoga and Rehabilitation: Physical, Psychological, and Social

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Editorial

Yoga and Rehabilitation: Physical, Psychological, and Social

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Received 30 September 2013; Accepted 30 September 2013

Yoga was intended for spiritual evolution [1], but increasingly nowadays it is used for its incidental benefits such as stress reduction and managing lifestyle related disorders. Despite its Indian origin, the number of yoga practitioners in Western society is growing: in the United States, for example, a national survey showed that 6.1% of the adults were practicing yoga in 2007 [2].

Apart from the benefits of Yoga practice in preventing and managing disease, yoga has several applications in rehabilitation (rehabilitare = to restore, in Latin). Rehabilitation is of different types such as (i) physical, (ii) psychological, and (iii) social. Yoga, as a way of life, has helped persons with physical disorders to return to health, an example being coronary artery disease [3, 4]. Other conditions which have benefitted from yoga practice include stroke after cerebrovascular accidents [5] and patients with heart failure, in whom exercise capacity, oxygen saturation, and parasympathetic activity were restored [6, 7]. Yoga breathing or pranayama was especially beneficial for COPD [8]. Practicing yoga has also been used with good results in degenerative disorders such as idiopathic Parkinson's syndrome [9] and muscular dystrophy [10].

With regard to psychological rehabilitation, yoga practice has helped restore the psychological function and mental equilibrium in persons with posttraumatic stress disorder [11] and even certain psychotic conditions [12].

Finally, yoga practice can help people who are at a disadvantage because of their social circumstances. This includes persons in jail [13], those from the “inner city” [14], children in remand homes [15, 16], and older people living in community centers [17, 18]. Social rehabilitation includes dimensions of physical and psychological rehabilitation.

Despite the research cited above, there is a continued need for research. A summary of yoga reviews pointed to the importance of larger-scale, rigorous research with higher methodological quality and adequate control groups.

Additionally, it should be stressed that although research should be aimed at yoga as a whole (hence including postures as well as meditation, respiratory practices, diet, and other aspects) this is obviously very complex, as the contribution of many different aspects cannot be easily identified, and confounding factors may play a decisive role. Also, the complexity and variety of different yoga techniques make a comparison between different studies very difficult. On the other hand, a “reductionist” approach seems to be more feasible from a scientific point of view, due to an easier separation of the specific effects of a single intervention (e.g., the analysis of one posture or the analysis of a single type of pranayama), but it is obviously at the risk of missing the whole effect of yoga. As a typical example, if one measures only the energy expenditure of a single yoga session, one may conclude that yoga will be of no use to lose weight, but other crucial effects of yoga related to weight control could be missed, such as the attention to diet and possibly a direct effect of pranayama on the hypothalamus, through which yoga does actually lead to weight loss. Thus, a careful balance between these opposite aspects needs to be taken into account when planning research on yoga.
The analyzed reviews suggested a number of areas where yoga may be beneficial, but more research is required for them to really establish such benefits. Nevertheless, some meta-analyses indicated that there are several randomized clinical trials of relatively high quality indicating beneficial effects of yoga for pain-associated disability and mental health [8]. Considering the large number of different yoga techniques and schools of yoga, it is also important for researchers to describe, in detail, the specific method used in a given study.

Yoga is worth investigating as it is relatively cost-effective, its practices can be adapted for different groups of patients, and if well oriented, the risks of side effects are very low. We hope that this special issue will give new insights for the development of novel, well-designed studies in the field of yoga and rehabilitation.

Shirley Telles
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The Improvement of Emotion and Attention Regulation after a 6-Week Training of Focused Meditation: A Randomized Controlled Trial

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Received 21 March 2013; Accepted 17 June 2013

Self-regulatory trainings can be an effective complementary treatment for mental health disorders. We investigated the effects of a six-week-focused meditation training on emotion and attention regulation in undergraduates randomly allocated to a meditation, a relaxation, or a wait-list control group. Assessment comprised a discrimination task that investigates the relationship between attentional load and emotional processing and self-report measures. For emotion regulation, results showed greater reduction in emotional interference in the low attentional load condition in meditators, particularly compared to relaxation. Only meditators presented a significant association between amount of weekly practice and the reduction in emotion interference in the task and significantly reduced image ratings of negative valence and arousal, perceived anxiety and difficulty during the task, and state and trait-anxiety. For attention regulation, response bias during the task was analyzed through signal detection theory. After training, meditation and relaxation significantly reduced bias in the high attentional load condition. Importantly, there was a dose-response effect on general bias: the lowest in meditation, increasing linearly across relaxation and wait-list. Only meditators reduced omissions in a concentrated attention test. Focused meditation seems to be an effective training for emotion and attention regulation and an alternative for treatments in the mental health context.

1. Introduction

From a psychological point of view, meditation is a broad term that refers to a variety of techniques that aim to develop self-regulatory skills in the emotional and cognitive domains [1]. There has been an increased interest in the scientific study of meditation practices, in both its clinical application in the health care context and in the understanding of its mechanisms of action [2, 3].
two months long can promote psychological improvements in patients with disorders such as social anxiety [7, 8], depression [9], and distress [10], as well as in healthy samples [11, 12].

It has been discussed that these outcomes likely reflect more adaptive emotion regulatory strategies, particularly better control of attention allocation, which allows the interruption of negative emotional processing [5, 13]. Noteworthy, attentional training constitutes one of the fundamental principles upon which meditation practices develop [3, 6], and it has been regarded as a cornerstone for any self-regulatory training from a cognitive perspective [14]. Thus, there seems to be an interesting parallel between psychological and meditation premises on how to foster emotion regulation.

Taking these considerations into account, the present study aimed to validate a secular focused meditation training by evaluating its effects on the ability to control attention allocation to negative stimuli in a healthy sample of undergraduates. The technique employed resembles dharana meditation [3], but, instead of using a mantra, it consisted of focusing attention on counting the out breath in order to avoid any direct link to a specific philosophy or doctrine in the university environment. The meditation group was compared to a relaxation and a wait-list control group, and the training schedule consisted of six weekly meetings.

Both emotion and attention regulations were assessed through a behavioral paradigm—the discriminative task [15]. The task comprises the random display of either a negative arousing or a neutral picture in the center of the screen, flanked by two peripheral bars. Participants are instructed to direct their eye gaze to the center while ignoring the task-irrelevant image and decide by a key press if the bars have the same orientation or not. There are two conditions, each requiring different levels of processing resources to succeed on the task. These are referred to as easy and difficult load conditions, in which subjects have to discriminate bars with a 90° or 6° difference in orientation, respectively. The emotion impact index is represented by the interference of the irrelevant negative image on the relevant attention task for each condition. According to the load theory [16], greater allocation of attentional resources to a relevant task may help reduce interference from irrelevant emotional stimuli. Thus, attentional deployment away from emotional stimuli, imposed by task constraints, may reduce emotional response and be an effective emotion regulation strategy [17, 18]. In the present study, we did not expect differences among groups for the difficult load condition, given that its exogenous attentional load was probably high enough to modulate emotion interference for all groups (see [15]). However, it was expected that in the easy condition only those trained in meditation would reduce emotion interference after training. Regardless of the low attentional load of the easy task, meditators were expected to have developed endogenous attentional control and greater attentional deployment away from the emotional stimuli [1]. Those trained only in relaxation or the wait-list controls were not expected to show such control.

Additionally, to further explore their attention regulation capacity, given that the task demanded an executive attention operation—paying attention to, discriminating, and deciding about the difference between two peripheral bars, we relied on signal detection theory (SDT) analyses [19]. In particular, the response bias index was used as it has been related to attentional control [20–22]. Response bias can be interpreted as the tendency to prioritize one of two answers, normally indicating that the subject adopts a strategy. In other words, it is a readiness to automatically give the same response [19, 23]. Given that attention training was an exclusive component of the meditation intervention and based on the importance of attention for self-regulation, we expected that only meditators would decrease response bias.

2. Methods

2.1. Participants. College students from the Universidade Federal do Rio Grande do Sul were invited to take part in the study through email and posters spread around its three campuses. Five hundred and twenty four students volunteered. After an online screening survey, participants were excluded if they were not in the range of 20–40 years old, did not have normal or corrected to normal vision, had any psychiatric or neurologic disorder, were taking any psychopharmacological medication, were undergoing psychotherapy treatment, and had had previous experience with meditation or yoga. One hundred students (57% female, 92% single, 81% with up to five minimum wage income, mean age 25 years, SD = 4.41) eligible for participation were randomly assigned to one of three groups: focused meditation (FM = 35), progressive relaxation (PR = 37), or wait-list control (WLC = 28). Seventy-four participants concluded the experiment (FM = 26, PR = 24, WLC = 24), of whom 41% were female, 70% single, 59% with up to five minimum wage income, and with a mean age of 25 years, SD = 4.44. None of these variables differed among groups (𝑃>.05), nor did attrition rates [χ²(2) = 3.60, 𝑃=.16]. The Federal University of Rio Grande do Sul Ethics Committee (Institutional Review Board) approved this study. Participants provided written informed consent before the data were collected.

2.2. Design. This study comprised a randomized controlled trial. For the discrimination task, we employed a 2 (distractors’ emotional load: neutral versus negative) × 2 (trial’s attentional load: easy versus difficult) × 3 (group: focused meditation versus progressive relaxation versus wait-list control) design with repeated measures on the first two factors.

2.3. Assessment

2.3.1. Screening

Sociodemographic Questionnaire. Created for the present study in order to investigate sociodemographic variables and exclusion criteria variables.

Self-Report Questionnaire—SRQ [24]. The SRQ consists of 23 questions that investigate minor and psychotic psychiatric symptoms through yes/no answers. The validated Brazilian version, whose sensitivity and specificity coefficients are 83% and 80%, respectively, was used [25]. The cutoff point for female and male was 7 and 6 positive answers, respectively.
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2.3.2. Pretest and Posttest

State and Trait Anxiety Inventory (STAI) [26]. The STAI comprises two scales measuring state and trait anxiety through twenty questions each. Answers are given on a 4-point Likert scale (1 = not at all, 4 = very much). The state and trait questions represent how the person feels at the present moment and normally, respectively. The higher the score, the greater the anxiety levels. The validated Brazilian version was used. Cronbach’s alpha for the state scale is .89 and .88 for the trait [27].

Concentrated Attention Test (Teste de Atenção Concentrada—AC) [28]. AC is a Brazilian psychometric test that assesses focused attention, with a test-retest coefficient of .73. For a maximum of 5 minutes, participants should mark only three types of triangles, among many others, all randomly distributed in rows on a paper sheet. Assessment of focused attentional performance includes correct answers, errors, omissions, and total score.

Adult Self-Report Scale—ASRS [29]. The ASRS consists of 18 items, contemplating attention deficit and hyperactivity disorder (ADHD) symptoms adapted to adult life. Answers are given on a 5-point scale (0 = never, 1 = rarely, 2 = sometimes, 3 = often, and 4 = very often). Positive answers include “often” and “very often,” and for some questions (items 3, 4, 5, and 9 for part A and items 2, 7, and 9 for part B) “sometimes.” Cut-off point for possible diagnosis includes a minimum of 6 symptoms in at least one domain (inattentive items 1–9 from part A and hyperactivity items 1–9 from part B), or both, and a score above 24 is considered highly suggestive of diagnosis. The ASRS was used in order to compare these symptoms across groups. If groups differed, this variable would be controlled for in AC and discrimination task analyses.

Discrimination Task [15]. Figure 1 illustrates the trial structure. Each trial initiated with a fixation cross, shown for 1,500 ms. Next, a central picture (9’ x 12’) and two peripheral bars (0.3’ x 3.0’) were presented for 200 ms. The bars were at 9’ to the right and left of the center of the picture. A whole-screen checkerboard mask was then shown, remaining on the screen until the subject responded or for 2,000 ms, which was the response deadline. The subjects were instructed to ignore the task-irrelevant central images and to respond as quickly and as accurately as possible whether or not the orientations of the peripheral bars were the same. Keypresses (with the right or left index finger) corresponding to same/different orientations (“q” or “p”) were counterbalanced across subjects. Two classes of images were employed: “neutral” (NE) and “emotional/unpleasant” (EM). Neutral images consisted of photographs of people, and unpleasant images consisted of photographs of mutilated bodies. We chose mutilated bodies because these are considered to be a very impacting category of emotional stimuli, likely to cause interference. Indeed, it has been already demonstrated that these images are efficient in generating an interference effect in the same paradigm used in the present study [15]. One hundred and twenty different images, 60 neutral and 60 unpleasant were utilized. A different set of pictures was used in the pretest and posttest sessions, and in each session pictures were repeated once. Forty-two images (14 neutral and 28 unpleasant) were taken from the International Affective Picture System (IAPS) developed by Lang and colleagues [30], and the remaining ones were obtained from the Internet. For the latter group of images, following the protocol developed by Lang and colleagues, all images were assessed on a 1–9 scale in terms of valence (from negative to positive) and arousal (from low to high) by a group of undergraduate students (N = 20, M_{age} = 22.3 years, SD = 1.8) using the paper-and-pencil version of the

Figure 1: Experimental design: a centered fixation cross was presented for 1,500 ms, followed by a central picture and two peripheral bars, presented simultaneously (for 200 ms) to the right and left sides of fixation. Then a checkerboard-like mask was presented; this remained on the screen until the response was made or 2,000 ms had elapsed. Subjects were instructed to ignore the central picture and attend to the peripheral bars, responding with a keypress as quickly and accurately as possible whether the bars were in the same or a different orientation.
Self-Assessment Manikin [31]. Overall, images in the neutral category had mean valence ratings of 5.0 and mean arousal ratings of 3.3; images in the unpleasant category had mean valence ratings of 2.2 and mean arousal ratings of 6.4. The experimental session started with three training blocks containing 20 trials each, which were followed by three regular blocks of trials (80 trials each). The order of neutral and unpleasant images within a block was randomized. During training blocks, all images were photographs of objects, such as tools and furniture. During each experimental block, the difficulty of the bar-orientation task was fixed. One “easy” (EA) and two “difficult” (DF) blocks were obtained by manipulating the angular difference of the bars on nonmatch trials: 90° in easy blocks and 6° in the difficult blocks. There were two difficult blocks to guarantee the necessary number of correct answers in this condition. Each block contained the same number of match and nonmatch trials and the same number of neutral and unpleasant images. Valence and arousal levels for emotional and neutral images presented in each block type were matched to avoid differences in emotionality between blocks. During the training blocks, participants received feedback, which indicated anticipatory responses (reaction times—RT—less than 100 ms), slow responses (RT greater than 2,000 ms), and whether an incorrect key was pressed; during training, the RT was also indicated on the screen after each trial. Experimental blocks, which followed the training blocks, lasted approximately 5 min each, and their order was randomized across subjects. The subjects sat approximately 60 cm from the display, and the stimuli were presented with the software E-Prime.

Task Ratings. Two analog scales were used to assess how anxious participants felt during the task (anxiety DT) and how difficult they thought the task was (difficulty DT). Answers were given on a 10-point scale (0 = not at all, 10 = very much).

Picture Ratings. Participants viewed the pictures previously presented in the task in order to assess their valence and arousal. In total, 4 blocks were presented: 20 negative pictures from the easy condition, 20 neutral pictures from the easy condition, 20 negative pictures from the difficult condition, and 20 neutral pictures from the difficult condition. For the difficult condition, because there were two blocks during the behavioral task, the 20 negative and 20 neutral pictures were randomly selected from both blocks. The set of images in the behavioral task was different from pre- to posttest. Thus, the set of images for the ratings was also different for pre- and posttest. For the 4 blocks in the picture rating, images were displayed for 1 sec, and in the end participants had 15 sec to rate the block using the paper-and-pencil version of the Self-Assessment Manikin [31]. For both valence and arousal subjects rated the block from 1 (very unpleasant and very relaxing, resp.) to 9 (very pleasant and very alerting, resp.).

Program Rating. At the end of the 6-week training, participants rated the meditation and relaxation programs’ quality (1 = very bad, 2 = bad, 3 = indifferent, 4 = good, and 5 = very good) and the usefulness of practices (1 = not at all, 2 = a little, and 3 = very much).

2.3.3. During Intervention

Practice Record. Every week participants received and completed a form to register the frequency and duration of practice at home.

2.4. Procedure. After advertisement, volunteers interested in taking part in the study were sent the screening questionnaires online. Those eligible to participate were contacted to schedule a visit to the laboratory for the pretest session, which occurred during two weeks prior to the beginning of the trainings for all participants. Two assessments, one at pretest and another at posttest (before and after training, resp.), were carried out at the Laboratory of Experimental Psychology, Neuroscience, and Behavior, at the Institute of Psychology, Federal University of Rio Grande do Sul. The following sequence of assessment was used: STAI-S, AC, STAI-T, discrimination task, task ratings, ASRS, and picture ratings. The reason for determining this sequence was two-fold: to avoid the influence of the experimental task in the anxiety measures, as well as in the concentrated attention test, and to avoid leaving the task for the last assessment, as this could affect performance due to the amount of previous testing. Students were randomly assigned to one of the three groups. FM and PR trainings included 6 weekly meetings, each lasting one hour and thirty minutes. For each of them, there were four concurrent groups undergoing training at different times during the week. Posttest sessions also occurred during the two weeks after the training, following the same assessment sequence. WLC participants did not have any activity between testing sessions but did receive the meditation training after final testing. Training sessions were conducted by one of the authors, a psychologist with group experience, extensive training, and regular personal practice of yoga and meditation. Meetings were held in classrooms in the three campuses. Training sessions always started with a brief discussion about participants’ weekly practice, difficulties, and experiences, followed by instructions, breathing exercises, formal practice—FM or PR—and again a brief discussion about the experience with that particular meeting. In the first and second meetings, formal practice lasted 15 and 20 minutes, respectively. For the following meetings, practices lasted 30 minutes. For the FM, participants could either sit cross-legged on a mat or on a chair with their feet on the ground. Because everyone was a beginner, they were instructed to pay attention to their own breathing, trying to slightly prolong the exhalation. Also, in order to characterize focused meditation, as well as to maintain their focus to this process and to the present moment, they were instructed to count their exhalation (mantras were not used in order to avoid any direct links to a specific philosophical or religious tradition). In the first half of the training, counting consisted of cycles from 1 to 10, and, for the next half, participants counted backwards from 100 to 1 (always one number per exhalation). PR sessions were formatted the same way, but all participants lay down on the mat for formal practice, which consisted of successive exercises of tension-relaxation for specific muscle groups [32]. A different muscle group was focused in each session (1st = wrists and arms; 2nd = face—forehead, eyes, nose, mouth, jaw; 3rd = neck; 4th = shoulders,
2.5. Statistical Analyses

2.5.1. Pretest. At pretest, a one-way ANOVA was performed to compare all self-report measures among groups and between gender.

For the discrimination task, all anticipatory and slow responses (<100 ms and >2,000 ms, resp.) were excluded from analyses; eliminated trials were infrequent at pre- and posttest (1.01% and 1% of the trials, resp.).

To explore the modulation produced by the emotional pictures we calculated the median reaction time (RT) and error rate (ER) for neutral and negative trials for each participant. These were the dependent variables, included in a factorial general linear model (GLM) for repeated measures considering load (easy versus difficult) and valence (emotional versus neutral) as within factors and group (FM versus PR versus WLC) as a between-subjects factor. We ran separate analyses for RT and ER.

A signal detection theory (SDT) analysis [19] was used to explore the effects of the meditation intervention over attentional control. First we calculated hits and false alarms, and response bias (k) analyses were conducted on the proportion of correct responses ((k) “Same” rate: the tendency to respond “same”, regardless of trial status) [19]. These were included in a GLM for repeated measures, with the same factors described above.

2.5.2. Posttest. At posttest, the same GLMs were again carried out but with time as an additional within-subjects factor (pretest versus posttest). ANOVAs, polynomial contrasts, and pairwise comparisons using t-test were applied when appropriate. For all analyses, the SPSS 20.0 was used, and the alpha level for statistical significance was P = .05.

3. Results

3.1. Pretest. All measures were compared between drop-outs (i.e., participants who did not complete the study) and completers (i.e., participants who completed training and both testing sessions), and no significant differences were found. There were neither differences nor interactions between completers’ groups in any of the variables analyzed. Of particular importance for this study, groups did not differ on attention deficit-hyperactivity disorder symptoms as measured by the ASRS (F(2, 88) = 1.81, P = .17, FM: M = 20.4, SD = 5.20, PR: M = 21.2, SD = 3.80; WLC: M = 22.00, SD = 3.40).

3.1.1. Discrimination Task. There were no differences among groups for any of the task analyses (P > .05). A general emotional interference produced by the presence of a negative picture while subjects performed the discriminative task was revealed by the main effect for valence in the RT (F(1, 94) = 11.59, P = .001). Participants were slower to perform the task when the central picture was negative (M = 600 ms, SD = 171) than neutral (M = 582 ms, SD = 148). The assumption that the difficulty of the bar orientation task was increased by reducing the angular difference between the bars was corroborated by a main effect of load in the ER outcome (F(1, 94) = 803.3, P < .001; DF > EA). As expected, error rates were increased during the difficult condition (M = 45%, SD = 8.2) in comparison to the easy condition (M = 11%, SD = 10.9).

Using signal detection theory analysis, results showed that in the difficult condition response bias was significantly greater (F(1, 96) = 117.6, P < .001; M = .73, SD = .18) than in the easy condition (M = .50, SD = .04).

3.1.2. Self-Report Assessments. There were no differences among groups (P > .05). Results are presented in Table 1.

3.2. Posttest

3.2.1. Practice Record and Program Ratings. Weekly practice for the FM group varied between 2 and 5 times (M = 3.01, SD = 1.06) and 17–115 minutes per week (M = 50 min., SD = 26.9). For PR, practice varied between 2 and 4 times (M = 3.03, SD = .94) and 17–76 minutes (M = 48 min., SD = 16.00). There were no significant group differences for these variables (P = .96, and P = .89, resp.). Program ratings did not differ between FM (quality: M = 4.60, SD = .49; usefulness: M = 2.80, SD = .42) and PR (quality: M = 4.50, SD = .50; usefulness: M = 2.80, SD = .36) (quality: t(48) = .45, P = .65; usefulness: t(46) = -.64, P = .52) groups.

3.2.2. Discrimination Task. The reaction time analysis of the emotional interference effect produced by viewing emotional pictures revealed an interaction between valence and time (F(1, 66) = 4.1, P = .045). Performing the discrimination task in the presence of an emotional picture was significantly different from neutral picture only at pretest (t(96) = 3.40, P = .001), but not at posttest (t(70) = 1.7, P = .09).

According to our hypothesis, we expected a reduction of the emotional effect of negative stimuli in the easy condition in the posttest session for the FM group. To test this difference, we created a variable to represent modulations in reaction time due to intervention. The variable was calculated by subtracting the reaction times in the posttest condition from the reaction times in the pretest condition for emotional and neutral images, each separately, and for each load condition (easy and difficult). Thus, there were a variable representing the subtraction in reaction time for the emotional images in the easy and in the difficult condition and a variable representing this subtraction for neutral images in the easy and the difficult condition. Negative values would indicate a reduction of picture interference on the main discrimination task. After performing a GLM for this variable for each load condition separately, results partially corroborated our hypothesis. We analyzed data from each load condition separately because, as discussed previously, they represent conditions with very different levels of neural resources available to
process the distractive pictures and group effect that were not expected to be present in the difficult load condition. We found a trend towards an interaction between valence and not expected to be present in the difficult load condition. We process the distractive pictures and group effect that were not expected to be present in the difficult load condition.

In order to make sure that this result indicated a reduction in the emotional interference by negative stimuli among meditators and not just a tradeoff between speed and error, we also created the same index subtracting ER for emotion images from pre- to posttest, and there were no group differences ($F(2,66) = 1.47, P = .23$).

Finally, to explore if the amount of meditation practice could predict the ability to reduce the emotional impact of negative stimuli in the easy condition, we conducted a linear regression analysis between mean days of weekly practice and the index of reduction of picture interference described above. Only in the FM group there was a negative relationship between number of days of weekly practice and the variable representing the reduction in RT for emotional images ($r = −.40, P = .04$) (Figure 3).

Considering the ER as the outcome, we found only a main effect for load ($F(1,66) = 689.4, P < .001; DF > EA)$).

For SDT analysis, response bias remained higher in the difficult condition ($F(1,68) = 81.1, P < .001; DF > EA)$ but was significantly reduced at posttest ($F(1,68) = 23.1, P < .001; pretest > posttest$). Importantly, there was a significant three-way interaction (load x time x group: $F(2,68) = 4.0, P = .02$). More specifically, in the easy condition at posttest, there was an increase in response bias only in the WLC (FM: $t(23) = −1.3, P = .18$; PR: $t(23) = 1.0, P = .28$; WLC: $t(22) =
show that experimental manipulation of attention reduces dose-response pattern. In the difficult condition, response bias in the emotional images was reduced, which followed a negative relationship between the number of days of weekly practice and the reduction in RT for emotional images. Finally, meditators presented a greater reduction in emotional reaction time (RT) compared to the easy condition, which was not explained by a tradeoff with error rate, and which was complemented by a reduction of interference produced by negative stimuli.[34].

Also, response bias followed a dose-response pattern at posttest, in which meditation practitioners presented the smallest bias, followed by relaxation and wait-list control (FM: t(23) = 5.6, P < .001; PR: t(23) = 3.6, P = .001; WLC: t(22) = 1.0, P = .29) (Figure 4).

Figure 3: Association between the mean number of days of weekly practice and the variable representing the post-pretest reduction in RT (ms) for emotional images in the easy condition for the FM group. Number of days of practice was not reported by six participants.

-2.7, P = .01), and in the difficult condition response bias was significantly reduced in the FM and PR groups (FM: t(23) = 5.6, P < .001; PR: t(23) = 3.6, P = .001; WLC: t(22) = 1.0, P = .29) (Figure 4).

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3.2.3. Self-Report Assessments. Table 1 shows results for self-report measures. After training, FM showed improvements in trait anxiety and some task ratings. Despite no significant interaction between group and time for concentrated attention parameters, paired comparisons revealed a significant reduction of omission errors only for meditation (FM: t(25) = 2.17, P = .03; PR: t(23) = 1.05, P = .30; WLC: t(21) = .53, P = .59). There were no significant correlations between amount of practice and any of the self-report measures for any of the active groups.

4. Discussion

The present study evaluated the effect of a six-week focused meditation training on emotion and attention regulation in a healthy sample of undergraduates, in comparison to a relaxation and a wait-list control group. Findings indicated that meditators presented greater reduction of emotion interference in the easy condition, which was not explained by a tradeoff with error rate, and which was complemented by a significant reduction in the subjective evaluation of negative valence and arousal of emotional images. Additionally, only meditators presented a significant reduction in state and trait anxiety and an increase in concentrated attention. Most importantly, the frequency of meditation practice predicted the reduction of interference produced by negative stimuli as revealed by a negative relationship between the number of days of weekly practice and the reduction in RT for emotional images. Finally, meditators presented a greater reduction in response bias in the difficult condition, which followed a dose-response pattern.

4.1. Meditation and Emotion Regulation. Behavioral studies show that experimental manipulation of attention reduces emotion interference produced by distinctive emotional stimuli, especially when attention load to the main task is high[15, 33]. This idea gives support to the present findings, in which meditators presented the most pronounced reduction in emotional interference after training and group differences were present only in the easy condition. The difficult condition consisted of a high exogenous attentional load task[34], facilitating attentional deployment away from the emotional stimuli. In this condition, task load was so high that it may have exhausted processing resources and reduced the processing of the distinctive emotional stimuli for all groups. However, in the easy condition, the task’s exogenous demands were lower, freeing up participants’ resources to process the distinctive pictures. In this condition, it was expected that emotional pictures would produce an interference on behavior, revealed by increased reaction times. The results showed that meditators were better to regulate interference from emotional pictures. Reaction times when negative stimuli were presented were reduced after meditation training. This indicates that meditators were able to control their attention better to perform the bar discrimination task, reducing the interference of emotional distractive information. Their increased ability to control attention allowed them more successfully to deploy attention as an emotional regulation strategy[17, 18].

One limitation, however, was the lack of a memory test for the images after the task. A better recall of emotional images might have indicated a more efficient use of divided attention, instead of better selective attention. Nevertheless, we believe this is not the case, given that meditators produced less negative valence ratings and lower arousal ratings. Also, they specifically practiced focused meditation, in which selective and sustained attendances are trained in order to inhibit distractions—internal or external—or disengage faster from them[1]. Studies investigating the efficacy of different emotion regulation strategies have demonstrated that selective attention allocation helps reducing emotional reactivity[18]. In fact, attention allocation may be more effective than other strategies, such as reappraisal and suppression[35–37], and one possible explanation relates to their temporal distinction, given that attention allocation takes place faster, impacting earlier stages of emotion-generative processes[38].

In line with these assumptions, other studies have also observed the efficacy of meditation for emotion regulation[39–41] and that psychological improvements following meditation training were mediated by enhanced top-down control[12, 42]. Interestingly, meditation can be more effective than distraction—an attention-allocation strategy—in reducing reactivity to negative self-beliefs related to social anxiety disorder[7]. One hypothesis for this outcome is the idea that meditation comprises a combination of an attentive mind with an emotional state of relaxation[3, 43, 44].

Our results showed that only meditators had a significant reduction in trait and state anxiety. This finding is particularly relevant, given that higher levels of anxiety can impair the regulatory process, biasing attention towards negative stimuli[45], or disrupting modulation of negative emotion[46]. Thus, cultivating attention stability along with a relaxation state seems to facilitate regulatory processes, possibly...
4.2. Meditation and Attention Regulation. As stated previously, response bias can be interpreted as the tendency to prioritize one of two answers, normally indicating that the subject adopts a strategy. In other words, it is a readiness to respond the same thing in an automated fashion [19, 23]. In the context of repeated two-option forced choices, like in our task, people present less persistence in doing subsequent cognitive tasks, either solvable or unsolvable, indicating that resource depletion is related to impaired executive control [47]. Thus, the fact that in the present study response bias was significantly higher in the difficult condition across groups at pretest, but significantly lower at posttest, particularly in the meditation group, suggests an improvement in their executive control.

This is in line with other studies that have used different selective attention manipulations to investigate response bias [20–22]. For instance, a three-week attention training aiming to help subjects ignore distractors and process the target more efficiently in an auditory selection task produced a significant reduction in response bias after training, which correlated with neural response as indexed by P3 amplitude [21]. In other words, the more attention subjects allocated to the target, the more controlled and less automated were their responses. Likewise, it has been shown that reversing a pattern of response bias was only possible through selective attention training but not through training in which the manipulation involved a high load cognitive operation [22].

Greater executive control has been demonstrated in people who have participated in meditation training programs, as well as in experienced meditators [48–50]. Similarly, areas typically involved in executive control, such as lateral prefrontal cortex and anterior cingulate cortex [51, 52], are more activated during meditation or during the execution of an attentional task by meditators when compared to controls [53–56].

It should be noted that one study which also used a discrimination task to investigate meditation effects on vigilance found no difference for response bias after a three-month meditation training [57]. However, in our results, response bias interacted with difficulty, and the task used by MacLean...
et al. did not include distractors nor had a condition that was more difficult than the other. Thus, in their study there might have been no reason for participants to adopt a strategy in the first place. In addition, participants were already meditators at pretest [57].

Finally, we highlight that this reduction is likely to have been intentional, goal-oriented, and not simply an inverse strategy or random response, because in the latter situations the result would have been accompanied by a higher error rate, which was not the case. Thus, in the difficult condition at posttest, meditators seem to have had more executive control over their goal-oriented behavior, which is in line with the hypothesis of greater attention efficiency in attention tasks among meditators [50, 58]. This regulation can also be inferred from the finding that only meditators significantly reduced omissions in the concentrated attention test, corroborating studies that used similar [3] as well as different measures of concentrated attention [59]. Importantly, given that a motivational reward, such as money, can facilitate attentional and conflict resolution performance [60], it is worth highlighting that our participants were not paid for their participation and that a potential interaction with this external motivational factor is ruled out in the present study.

4.3. Meditation as a Psychological Rehabilitation. Our results corroborate the idea that emotion and attention regulation are intertwined and that meditation can enhance these skills. Moreover, meditation seems to constitute a particular type of emotion regulation strategy, which can be clinically relevant. It is known that in some psychiatric patients, even in remission, such as remitted depressed patients, there is a difficulty in reducing amygdala's reactivity to negative emotional stimuli when using reappraisal, and this correlates with the report of significantly less use of such strategy on a daily basis [61]. Likewise, there is evidence showing that anxiety patients present a bias favoring amygdala overactivation, as well as under-recruitment of prefrontal areas in the processing of negative stimuli [45].

Thus, self-regulation practices, such as the meditation training proposed in the present work, seem to be an alternative for clinical conditions, especially considering the early effects of attention on emotion response [38], and the fact that early reactivity to emotional stimuli may modulate subsequent processing stages [62]. Accordingly, Farb et al. [13] have recently discussed that among patients with affective disorders, mastering the direction of attention can help limiting the cognitive elaboration of negative emotions and negative self-evaluation.

These assumptions are in accordance with studies that have demonstrated a positive effect of meditation training in psychiatric symptoms and disorders [5, 7, 63, 64]. For instance, a meta-analysis showed that in patients with anxiety and mood disorders the effect sizes of meditation-based interventions were very robust, independent of year of publication, and maintained over follow-up [65]. It should be noted that in addition to its therapeutic effects, meditation could also contribute to mental health practices by fostering therapist's effectiveness, therapeutic alliance, and complementary perspectives on therapeutic processes [4].

Acknowledgment
This study was funded by the National Council for Scientific and Technological Development (CNPq), FAPERJ, and CAPES.

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Review Article

Yoga and Mindfulness as Therapeutic Interventions for Stroke Rehabilitation: A Systematic Review

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Received 28 March 2013; Accepted 8 May 2013

Academic Editor: Marc Cohen

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Aim. This paper reports a systematic review and critical appraisal of the evidence on the effectiveness of behavioral therapies such as yoga and mindfulness practices for stroke rehabilitation. Background. The experience of stroke can have a negative impact on both psychological and physical health and on quality of life. Yoga and relevant practices are promising therapies that have been used with patients with a variety of conditions. In order to draw conclusions on effectiveness for stroke patients, the evidence requires systematic assessment. Methods. A comprehensive search of major biomedical and complementary medicine databases was conducted. Relevant research was categorized by study type and appraised according to study design. Results. Five randomized controlled clinical trials and four single case studies were found. Additionally, one qualitative research study was identified. Studies reported positive results, including improvements in cognition, mood, and balance and reductions in stress. Modifications to different yoga practices make comparison between studies difficult, and a lack of controlled studies precludes any firm conclusions on efficacy. Conclusion. Yoga and mindfulness could be clinically valuable self-administered intervention options for stroke rehabilitation. Further research is needed to evaluate these specific practices and their suitability in stroke rehabilitation.

1. Introduction

Stroke is one of the most prevalent diseases worldwide causing devastating impairments and negative consequences for survivors [1]. Moreover, it is a main cause of adult-onset disability among people and the cost for care is among one of the fastest-growing Medicare expenses [2]. Poststroke therapy may improve recovery and reduce long-term disability [3], but more psychological therapies for evaluating the specific effects of rehabilitation are needed. Given that many rehabilitation programs currently offer yoga as an option to patients, and that yoga is included as a therapeutic option in a number of rehabilitation medicine texts [4–6], a systematic review of its importance warrants further investigation.

Yoga and mindfulness can be regarded as a main form of alternative medicine therapy [7]. Yoga is an ancient tradition coming from the Sanskrit word “yoga” meaning union or one-pointed awareness. In the Yoga sutras, Patanjali defined the word “yoga” in the first sutra as Atha yoga anushasanam, which means “yoga” is a form of discipline [8]. The word “anushasan” can be broken down into two parts: “anu” meaning “the subtle aspects of human personality,” and “shasan” meaning to “rule over” or to “govern” [9]. Therefore, the concept of yogic discipline is knowledge of the subtle dimensions, the aspects of human personality and directing or governing the subtle nature. In the absence of this discipline there will always be a search to find happiness and harmony, a persistent sense of emptiness inside, and a feeling of not fulfilling or deriving the best from life. Yoga exercises foster willpower, discipline, and self-control and force the mind and body to work in perfect synergy. Therefore, yoga exercises may have beneficial effects as a stand-alone treatment on stress reduction and overall well-being [10, 11]. In addition, yoga has been seen as a main discipline and practice that has the potential to cultivate mindfulness [12]. However, most literature has focused on...
mindfulness that is developed through yoga meditation [13], a self-regulation practice that focuses on training attention and awareness in order to exhibit a mental process that reinforces mental health well-being and mental stability.

Dr. John Kabat-Zinn, in late 1970, while teaching mindfulness and hatha yoga in Boston, noticed that his trainees were seeking both hatha yoga practices, including asanas (physical exercises), and mindfulness meditation. Therefore, he and his colleagues developed a clinical service that used relatively intensive training in mindfulness meditation practices based on the Vipassana and Zen traditions, along with hatha yoga, for medical patients suffering from a wide range of chronic disorders and diseases [14]. This program evolved into an 8-week course, now known as mindfulness-based stress reduction (MBSR), which is taught worldwide in different centers internationally [15]. Noticeably, practicing mindfulness meditation does not confute the practices of yoga [16]. One practice acts complementary to the other depending on how it is taught and what the needs of the trainees are.

Mindfulness can be defined as a cognitive process that employs the creation of new categories, openness to new information, and awareness of more than one perspective [17]. Dr. Hirst suggests that being mindful requires the person to attend, to be consciously aware of the emergent nature of phenomena in consciousness, and to recognize the nature of attachments made to these phenomena as they occur [18]. Mindfulness, according to Dr. Kabat-Zinn et al. [19], is based on Eastern contemplative tradition and involves “bringing one’s attention to the present experience on a moment-by-moment basis” [14, 15]. On the other hand, Professor Langer discusses the cognitive model of mindfulness without emphasis on the meditative part [17]. She believes that mindfulness could be easier understood with the opposite concept: a state of being as if on automatic pilot, involving preoccupation, absent mindedness, carelessness, in attention, disassociation from feelings, thoughts, actions, and habitual responses. Meanwhile, there is now considerable evidence of the effectiveness of mindfulness-based interventions at reducing distress [20, 21] and rehabilitation [22, 23].

Notably, there are many different kinds of hatha yoga and mainstreams based on the multiple traditions that they follow [4, 11, 24]. Thus, the present review will attempt to address this gap within the literature and synthesize the existing research on the positive effects of yoga and relevant meditative practices on stroke rehabilitation.

2. The Present Review

The aim of the present review is to conduct a systematic review of the literature concerning holistic therapies such as yoga and mindfulness as a therapeutic application on stroke rehabilitation. Specifically, only studies evaluating the yoga effects on stroke patients were included.

3. Materials and Methods

3.1. Overview Methodology. The process used for this literature review was highly structured and comprised a number of distinct phases. First, there was the “searching phase,” which involves the systematic identification of potentially relevant studies. The second phase was the “screening phase,” where a predetermined inclusion and exclusion criteria were applied, allowing us to identify appropriate studies for review. In the third phase, or “data-extraction phase,” studies that met the pre-determined inclusion and exclusion criteria were examined in-depth to assess the quality of the study and extract evidence for synthesis. In the fourth stage, or “synthesis phase,” the authors developed a framework for analyzing the selected materials. Finally, in the “reporting phase,” the authors decide on the most efficient and assessable way to present their findings.

3.2. Search Terms. The terms used for stroke were based primarily on those used by the Cochrane Cancer Field [35]. The terms used were stroke and mindfulness, MBSR, yoga, pranayama, dhyana, asanas, yogic, meditation, meditat, transcendental meditation, or mindfulness.

3.3. Search Databases. Systematic searches included major biomedical, nursing, and specialist complementary therapy databases including MEDLINE, EMBASE, AMED, CISCOM, CINAHL, PsycINFO, PubMed, Web of Science, Science Direct, EBSCO, Scopus British Nursing Index, and the Cochrane Library. A search of specialist resources included Cochrane Complementary Field Registry and other Cochrane Specialist Registries. Search strategies were developed to accommodate the different indexing approaches used by the databases [36]. Efforts were made to identify unpublished and ongoing research using relevant databases such as the National Research Register (UK) and Clinicaltrials.gov (USA) together with contacting experts in the field. Reference lists of relevant articles were reviewed to identify further studies.

3.4. Filtering. Potential research papers were noted for retrieval and given a preliminary “study type” classification as systematic reviews, randomized controlled trials (RCT), single case reports, qualitative research, or conferences presentations. Animal and basic laboratory-based studies were not included in the categorization process since these settings require a different design procedure. Two reviewers carried out this process independently, notes were compared, and in cases of disagreement these papers were also retrieved.

3.5. Inclusion Criteria. Studies written in English, were conducted between 1990–2013, drawn for published research, used yoga or relative meditative/mindfulness practices as an intervention in stroke rehabilitation, were case control and randomized control trials or cohort studies were included. We included any form of yoga practice, including meditation, pranayama, hatha yoga (which is part of the mindfulness stress reduction program). Posters or oral presentations published in scientific journals were included.

3.6. Exclusion Criteria. Studies that were not conducted in English, were conducted before 1990, drawn from
unpublished work, used yoga as an intervention for treating other diseases, or were based on a single person's opinion were excluded from the review.

4. Results

No systematic reviews relating specifically to stroke rehabilitation and yoga therapy were identified except for one combining a systematic review and results from a pilot study [26]. In total ten studies were identified meeting the inclusion and exclusion criteria. Out of ten studies, five were randomized control studies [21, 25, 28, 31, 33, 34], four were single case report studies [26, 27, 30, 32], and one was a qualitative study [29]. These studies were conducted in USA (n = 5), Canada (n = 1), Switzerland (n = 1), Saudi Arabia (n = 1), and Australia (n = 2) between 2003 and 2013. Among them, there were five randomized control trials (RCTs), which employed two arms. Six of these studies used the sham intervention for the control groups. None of the studies used a double-blind design. Interestingly, all studies found and conducted after 2003 discussed the relative novelty of the specific therapy for stroke rehabilitation. After 2010, a growing interest particularly in stroke rehabilitation and development of novel alternative therapies in stroke survivors was noticed. Therefore, yoga and mindfulness techniques seem to be an increasing topic of interest, urging the need for more focused investigations to evaluate their effectiveness. All studies included are presented in Table 1, together with comments on their methodology and clinical relevance. Trials are also further discussed in narrative form in order to illustrate differences between studies and in an attempt to assist in highlighting the issues to be addressed in future directions. It was not possible to combine the results of studies due to the variation in the interventions and outcome measures.

4.1. Randomized Controlled Trials. Schmid et al. [25] explored whether an 8-week yoga intervention would impact the rehabilitation of veteran stroke survivors. Even though there were no significant differences between the control and experimental groups in the independent tests, within-group tests showed a significant improvement in balance in the yoga group. Chan et al. [37] applied a 6-week yoga intervention in stroke survivors. Depression and anxiety were measured before and after test. Changes in depression and state and trait anxiety did not significantly differ between interventions. However, comparison of individuals’ case results indicated clinically relevant improvements in both groups, with members of the intervention group having a greater improvement. Johansson et al. [31] applied an 8-week mindfulness-based stress reduction program (MBSR) for traumatic brain injury and stroke patients focusing on mental fatigue. After the MBSR, improvements in mental fatigue were found in stroke survivors [31]. John et al. [33] explored whether a 6-week yoga intervention would impact disability, balance, fatigue, and depression. Results indicated that the meditation group improved significantly in all measurements after training.

4.2. Single Case Studies. Bastille and Gill-Body [27] examined the effects of a yoga-based therapy intervention on mobility and balance in four stroke patients at least 9 months following stroke. The small number of participants did not allow for statistical analysis on the significance of the findings. However, the authors chose to report the findings in a single subject, before and after study design. The investigators reported improvement on the Berg balance score in two of the participants following the intervention and improvement on the timed movement battery in three of the participants. A measure of improvement was seen as a change of at least two standard deviations from the baseline in each patient. Lynton et al. [26] assigned 3 participants into a Kundalini yoga program for 2 weeks. Dexterity and speech improved significantly after the interventions relative to baseline. However, due to the small sample size, it was impossible to draw definite conclusions, but the positive trends in this study suggest that further research should be conducted. The study designed by McEwen et al. allowed the patients to choose the interventions and goals they wished to set. The three goals selected by one participant were clipping the nails on his left hand by using clippers with his affected right hand, walking while carrying an object in his affected right hand and learning basic yoga or deep breathing techniques. Improved performance for this participant was maintained at a 1-month followup for all but one goal, yoga [30]. Finally, Hofer et al. [32] applied a treatment for stroke, which was a combination of neuropsychological interventions, psychoeducation, cognitive-behavioral therapy, and mindfulness techniques. For the patients with poststroke fatigue (PSF), the central goal was to learn better coping skills regarding their increased vulnerability to fatigue. The significant changes in the symptoms of PSF as well as the achievement of the individually formulated therapy goals support the notion that mindfulness enhances the adjustment process to PSF.

4.3. Published Posters or Oral Presentations. Van Puymbroeck et al. [34] designed a 10-week yoga intervention for improving quality of life in stroke survivors. To measure activity and participation, the International Classification of Functioning, Disability and Health (ICF) measure of participation and activity (IMPACT) subscales were used. To measure quality of life, the stroke survivor’s quality of life (SSQOL) scale was distributed to participants. Results showed significantly improved activity, participation, and quality of life in the yoga group compared to the control group.

4.4. Qualitative Studies. Garrett et al. [29] conducted a qualitative study exploring participants experiences after a yoga program. After the intervention, participants reported greater sensations, feelings of tranquility, and becoming connected to their body and self. These themes respectively revealed perceived physical improvements in terms of strength, range of movement or walking ability, an improved sense of calmness, and the possibility for reconnecting and accepting a different body. This study implies yoga's positive outcomes and sets the base for future quantitative investigations [29].
Table 1: Yoga as a therapeutic intervention for stroke rehabilitation.

| Authors (Year) | Groups | Outcome measures | Sample | Design | Interesting finding |
|----------------|--------|------------------|--------|--------|---------------------|
| Schmid et al., 2012 [25] | Wait list (control) Yoga | (1) Disability independent (2) Fear of falling (3) Balance (4) Balance self-efficacy (5) QOL | Control: 
  *N* = 10
  Yoga: 
  *N* = 37
  Stroke patients Veterans | RCT 8-week intervention | In within-group comparisons, yoga group data demonstrated significant improvement in balance |
| Lynton et al., 2007 [26] | Yoga | (1) O’Connor tweezer dexterity (2) Boston aphasia exam | Stroke patients 6 months after stroke Beth Israel Medical Center, NY, USA | Single case study 2 weeks Kundalini yoga practice | All 3 participants showed improvement on dexterity |
| Bastille and Gill-Body, 2004 [27] | Yoga | (1) Berg balance scale (2) Timed movement battery (3) Stroke impact scale | Stroke patients <9 months after stroke Keene, NH, USA | Single case study 4–7-week baseline period followed by 8-week intervention yoga practice | 3 subjects had improved TMB scores, and 2 subjects had improved BBS scores |
| Chan and Woollacott, 2007 [28] | Exercise group (control) Yoga exercise group (intervention) | (1) Geriatric depression scale (2) State trait anxiety inventory | Control: 
  *N* = 6
  Yoga: 
  *N* = 8
  Poststroke population Royal Adelaide, Hospital South Australia | Single-blinded RCT 6-week standardized program that included home practice | Participants in both groups exhibited a mixture of decreases, increases, and no changes in GDS15, STAI-Y1, and STAI-Y2 over the course of the trial |
| Garrett et al., 2011 [29] | Wait list (control) Yoga (intervention) | Biopsychosocial model (1) Physiological experiences (2) Psychological experiences | Control: 
  (N = 12)
  Yoga: 
  (N = 10)
  Individuals with chronic poststroke hemiparesis 9 months after stroke South Australia | Qualitative RCT 10-week yoga program involving movement, breathing, and meditation practices | Participants reported greater sensation, feeling calmer, and becoming connected |
| McEwen et al., 2009 [30] | Yoga | (1) Performance quality rating scale (10 pt. scale) (estimate values) (2) Canadian occupational performance measure (3) Stroke impact scale (4) Stanford self-efficacy for managing chronic disease (6-item scale) (5) Activity-specific balance confidence | Rehabilitation center 1 year after stroke Toronto, Canada | Single subject study with 2 replications CO-OP intervention conducted over ~10 sessions | Intervention was associated with significant performance improvements in self-selected functional goals |
### Table 1: Continued.

| Authors                  | Groups                        | Outcome measures                                                                 | N    | Sample                          | Design                  | Interesting finding                                                                 |
|--------------------------|-------------------------------|----------------------------------------------------------------------------------|------|---------------------------------|-------------------------|-------------------------------------------------------------------------------------|
| Johansson et al., 2012 [31] | MBSR Treated/ control         | (1) Self-assessment of mental fatigue (MBSR)                                    | N = 29 | Stroke Stroke (N = 18) TBI, (N = 11) MBSR (N = 12) | RCT 8-week MBSR        | MBSR may be a promising nonpharmacological treatment for mental fatigue after a stroke or TBI |
| Hofer et al., 2012 [32]   | Yoga                          | Mental fatigue and related symptoms after neurological disorders and injuries (SQMF) | N = 8 | Stroke patients University Hospital of Bern | Single subject study MBCT | Significant pre- to postassessment differences were observed in patients in poststroke fatigue |
| John et al., 2010 [33]    | Group A (film/music) Group B (meditation) Group C (control) | (1) Hamilton rating scale for depression (2) Berg balance scale (3) Barthel ADL index (4) Fatigue severity scale | N = 60 | Stroke patients Saudi Arabia | RCT 6-week intervention Pre- and postcontrol group design | Music therapy and meditation are more beneficial than conventional physiotherapy management alone |
| Van Puymbroeck et al., 2012 [34] | Yoga/wait list (control)     | Stroke survivor's quality of life (SSQOL)                                       | Yoga (N = 37) WL control (N = 10) | 6 months since last stroke USA | RCT 3:1 ratio 8-week yoga intervention | Results showed improved activity, participation, and quality of life relative to controls |

nr: not reported, WL: Wait list, RCT: randomized control trial, MBSR: mindfulness-based stress reduction program, MBCT: mindfulness-based cognitive therapy.
5. Discussion

The authors of this systematic review suggest that yoga is a useful tool for the rehabilitation process after stroke. Since stroke is a leading disease, the need for effective tools for rehabilitation is vital. All studies in the systematic review focused on mood, fatigue, stress, cognitive ability, and quality of life after stroke. This review shows that yoga and stroke rehabilitation have seldom been addressed. Therefore, this systematic review highlights the lack of definitive evidence of yoga’s efficacy in stroke rehabilitation and suggests that this topic warrants future investigation. Methodological limitations of the studies included in this review were small sample sizes, limited descriptions of the randomized process when applicable, lack of reporting sampling methods, reasons for dropouts, and insufficient description of specific yoga or meditative practices.

Focus on cognitive functionality after stroke is suggested for future studies, since stroke patients suffer from cognitive dysfunction. One of the most vital problems when comparing different yoga interventions or mindfulness programs is that they are multimodal interventions with mindfulness as their focus. In a pragmatic trial this might not play a vital role but it does have implications for replication and transferability of the study. Moreover, yoga interventions and MBSR programs applied for stroke survivors so far have had relatively small samples and may be unpowered. Yoga interventions should therefore be designed to meet patients' different characteristics (time after stroke, level of impairment, function, and mobility). Physical changes in the form of improved mobility, motor coordination and cognitive changes in the form of improvement of speech impairments seem to be the main components that stroke survivors could benefit from [26].

Through the methods of body posture, breathing training, and consciousness meditation, overall well-being could be improved with positive benefits to the nervous system [38], endocrine system [39], cardiovascular system [40], respiratory system [41], and immunity [42]. Few studies have demonstrated the effects of mindfulness and yoga on well-being, somatic effects of stress, immune system and physical symptoms and chronic conditions [43, 44]. After meditation practice, results showed that the density of gray matter increased in regions governing distinct different activities as memory, self-awareness, and compassion. Additionally, grey matter decreased in the amygdala, the part of the brain associated with fear and stress [45]. In a more recent study, relaxation techniques seem to affect the genes involved in controlling how the body handles free radicals, inflammation processes, and cell death [46]. More specifically, relaxation techniques improve mitochondrial energy production and utilization and thus promoting mitochondrial resiliency through the upregulation of ATPase and insulin function [46].

Interestingly, there was no identified study exploring the neurobiology and plasticity of stroke patients after a yoga or mindfulness-based intervention. There is now considerable evidence of MBSR yoga programs on brain alteration and structural and functional plasticity [45]. Recently, several cross sectional anatomical MRI studies have demonstrated that experienced meditators exhibit a different gray matter morphometry in multiple brain regions suggesting plasticity when compared with nonmeditating individuals [45, 47–52]. Four case control studies recently showed significantly higher levels of selective attention in meditators compared to controls, with some specific differences across trials [37, 53–55]. Other results suggest that mindfulness training may improve attention-related behavioral responses by enhancing functioning of specific subcomponents of attention. Whereas participation in the MBSR course improved the ability to internally orient attention, retreat participation appeared to allow for the development and emergence of receptive attention skills, which improved external alerting-related process. Those findings could have dramatic effects for stroke survivors since cognitive skills (thinking, reasoning, judgment, and memory) are mainly impacted. Emotional liability is another component following stroke where mindfulness could have beneficial effects. Mindfulness training is suggested to decrease cognitive rumination, [56] an important component of self-critical elaboration linked to midline prefrontal cortex (PFC) and reactivity in depression [57–59]. The midline PFC seems to be connected to negative-mood induction [59] and exposure to negative-self beliefs [60]. MBSR programs have been associated with decreased activation of these cortical midline structures [59, 60], and efforts to mindfully attend to experience can reduce cortical midline activity in beginners [59]. Several other studies have observed more extensive reductions in cortical activity during meditation, [45, 61, 62] an effect that appears to increase with greater mediation experience [63]. Thus, it may be deduced that one function of mindfulness training is to reduce negative or self-critical judgment associated with cortical midline activity. Additionally, hatha yoga practices could help in limb rehabilitation in stroke survivors. Mindfulness and yoga practices might improve poststroke hemiparesis, [27] although more focused research is needed to determine their effectiveness.

Finally, these findings are of vital importance since problems of emotional processing, including impaired mood, emotion regulation, and emotion perception, are known to occur following stroke and can detrimentally influence many aspects of social interaction after stroke. We suggest that investigations using magnetic resonance imaging (MRI) and magnetoencephalography (MEG) as biomarkers of cognitive brain functions are needed in stroke survivors. Moreover, targeted interventions such as yoga and mindfulness as forms of cognitive therapy should be used addressing specific patients’ needs and contraindications. Yoga and mindfulness interventions are a novel therapeutic approaches to personalized alternative medicine that encourages patients to improve their body and mind health by incorporating both new practices and philosophy in life.

6. Conclusions

Yoga seems to offer a relief from a long list of medical ailments in stroke by alleviating both the mind and the body from stress. Yoga and meditative practices act on both the psychological and physical levels, and improvements
have been noticed in patients’ mindsets [25]. For example, participants in one study [25] talked about incorporating physical activity in their everyday lives more than they used to after yoga intervention. These changes in the mindsets of people with disease can potentially lead to a change in behavior and ultimately an improvement in health [17]. Therefore, the moderating role of mindset and its ability to enhance health should be identified further, substantiated, and utilized in future directions.

**Appendix**

For more details, see Figure 1.

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Affect and Mindfulness as Predictors of Change in Mood Disturbance, Stress Symptoms, and Quality of Life in a Community-Based Yoga Program for Cancer Survivors

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Received 21 December 2012; Revised 27 March 2013; Accepted 11 April 2013

Academic Editor: Luciano Bernardi

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Little attention has been paid to the psychological determinants by which benefits are accrued via yoga practice in cancer-related clinical settings. Using a longitudinal multilevel modeling approach, associations between affect, mindfulness, and patient-reported mental health outcomes, including mood disturbance, stress symptoms, and health-related quality of life (HRQL), were examined in an existing seven-week yoga program for cancer survivors. Participants (N = 66) were assessed before and after the yoga program and at three- and six-month follow-ups. Decreases in mood disturbance and stress symptoms and improvements in HRQL were observed upon program completion. Improvements in mood disturbance and stress symptoms were maintained at the three- and six-month follow-ups. HRQL exhibited further improvement at the three-month follow-up, which was maintained at the six-month follow-up. Improvements in measures of well-being were predicted by initial positive yoga beliefs and concurrently assessed affective and mindfulness predictor variables. Previous yoga experience, affect, mindfulness, and HRQL were related to yoga practice maintenance over the course of the study.

1. Introduction

Receiving a cancer diagnosis, undergoing treatment, and the subsequent recovery takes a great toll on many cancer survivors. Psychosocial distress stemming from the cancer experience is a significant problem for up to half of all cancer patients, and many survivors experience lowered overall health-related quality of life (HRQL) during and following active treatment [1]. Regardless of intervention specifics, exercise enhances a variety of HRQL and psychosocial outcomes in various cancer survivor groups both during and after cancer treatment and may also help to manage the long-term side effects of treatment [2].

Within the larger field of exercise and cancer, yoga is often considered a gentle, low-intensity form of exercise [3]. The unique integration of both moving and static sequences (asana), breathing exercises (pranayama), and different meditation tools to withdraw the senses (pratyahara), concentrate the mind (dharana), and develop abilities of impartial awareness (dhyana) have all been used as means of increasing performance and recovery in both general and clinical populations [4]. These practices are routinely modified based on desired outcomes as well as participant health status [5]. Studies comparing the effects of yoga and exercise indicate that, in both healthy individuals and those with various health conditions, yoga may be as effective as more common forms of
exercise, including walking, jogging, cycling, and aerobics, at improving a variety of health-related outcome measures [6]. Within clinical cancer settings, those participating in a yoga intervention compared to waitlist control groups or supportive therapy groups showed greater improvements in overall HRQL, psychological health, stress-related symptoms, sleep and fatigue indices [7–12]. However, these reported improvements in cancer survivors practicing yoga have not been uniform [13].

2. Theory

As research in the use of yoga in cancer-related clinical settings continues to grow and yoga is integrated into cancer care, it is imperative the clinical benefits of yoga for cancer survivors are better understood. Identifying predictors that explain how yoga leads to clinically significant outcomes is the next step in understanding the ability of yoga to target desired outcomes. Recommendations from the UK Medical Research Council [14] suggest time spent examining predictors, both theoretically and practically, help to strengthen the causal chain of evidence and further refine both the interventions themselves and research design. The proposed predictors tested in the current study include affect regulation and mindfulness.

2.1. Affect Regulation. Positive affect is theorized to be an independent, adaptive pathway in the cancer experience [15]. Positive affect can be broadly defined as feelings associated with pleasurable experience that may elicit descriptors such as happiness, joy, contentment, and peacefulness [16]. Both baseline positive affect and the enhancement of positive affect are important components of symptom management and cancer recovery [17]. In general, exercise increases positive affect and reduces negative affect [18] and individuals tend to choose and adhere to physical activity associated with positive affective experiences [19]. In cancer-related clinical settings specifically, fostering positive affective experiences via a structured exercise program is an important target for interventions designed to facilitate postprogram exercise adherence [20].

Participation in a single yoga session has been associated with significant improvements in positive affect and reductions in negative affect, comparable to changes seen with aerobic exercise [21, 22]. Findings from a pilot randomized-controlled trial (RCT) examining the effects of a 10-week restorative yoga program in breast cancer survivors on or off treatment suggest significant benefits favoring the yoga group on positive affect, mental health, depression and spirituality outcomes [23]. Findings from a second pilot RCT examining the effects of a 12-week yoga program in breast cancer outpatients undergoing adjuvant radiotherapy reported significant improvement in positive affect, emotional function and cognitive function, and decreased negative affect in the yoga group as compared to controls [24].

2.1.1. Circumplex Model of Affect. Given the proposed importance of positive affect and exercise and yoga's influence on this phenomenon, the Circumplex Model of Affect [25] offers an encompassing yet parsimonious explanatory approach for conceptualizing and assessing changes in affect. At the heart of mood and emotion are underlying psychophysiological states experienced as simply feeling good or bad, energized or fatigued. According to the Circumplex Model, the affective domain can be represented by a circle defined by two orthogonal and bipolar dimensions: valence (pleasure versus displeasure) and perceived activation or arousal (high versus low). These two dimensions of valence and activation, termed core affect, underlie all affective states. Four states derived from the combination of these two dimensions can be described as high-activation pleasure (e.g., energy), low-activation pleasure (e.g., calmness), high-activation displeasure (e.g., tension), and low-activation displeasure (e.g., tiredness) [26] (see Figure 1). Based on these two dimensions and four quadrants, a host of affective responses, emotions and moods are possible. The Circumplex Model of Affect has been recommended as a conceptual framework for measuring core affect given the dimensional approach allows capture of the constituent elements of a larger range of basic affective states [27].

2.2. Mindfulness. Mindfulness is the systematic development of the ability to nonjudgmentally direct attention towards events in the field of consciousness in the present moment [28]. Emerging research findings suggest both trait and state mindfulness are related to affect regulation [29]. Specifically, the various extant measures of mindfulness and practices that engender higher reported mindfulness have been associated with higher reported positive affect and lower reported negative affect, perhaps through engagement of attention upon immediate experience [30].

It has been suggested yoga adds a contemplative element to exercise and can be conceptualized as “mindfulness in motion” [31]. Specifically, the practice of yoga provides an opportunity for sustained attention to physical sensations, breathing, and mental activity through progressive sequences of dynamic movements, restful postures, breathing exercises, and periods of meditative awareness [32]. However, research evidence linking yoga practice to these changes in mindfulness remains equivocal. Lengacher and colleagues [33] found minutes of yoga practice as part of the overall Mindfulness-Based Stress Reduction (MBSR) program was not significantly related to positive changes in psychosocial status and HRQL in a breast cancer survivor population. However, these findings are in contrast to the work of Carmody and Baer [34], whose research in a noncancer heterogeneous medical population found the yoga component of an MBSR program to be most strongly related to improvements of mindfulness measures, psychological symptoms and perceived stress. These findings have more recently been corroborated in a study by Sauer-Zavala and colleagues [35], which reports yoga practice was associated with greater psychological well-being independent of equivalent amounts of a supine body scan or seated meditation practice in an undergraduate student population.
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2.2.1. Facets of Mindfulness. Five facets of mindfulness have been described as follows: the ability to (1) observe and (2) describe experiences in the present moment while (3) acting with awareness (4) without judgment or (5) prolonged reaction [36]. In cancer-related clinical settings, work by Bränström and colleagues [37] suggest prepost changes in facets of mindfulness mediate changes in psychological outcomes both post-MBSR program and at a three- but not six-month follow-up [38]. Recent work by Garland and colleagues [39] is consistent with these findings, indicating significant relationships between increased facets of mindfulness and reductions in mood disturbance and stress symptoms.

Cancer-related distress and lower HRQL are prevalent among many cancer survivors. Exercise is effective in ameliorating this distress and improving HRQL. Yoga can be considered a low-intensity form of exercise that has been shown to independently improve HRQL, psychosocial outcomes and symptom indices. Two posited predictors of these improvements are increased positive affect and increased mindfulness.

3. Objectives

Given preliminary evidence that yoga practice is associated with (1) increased positive affect, (2) heightened mindfulness, and (3) improved HRQL and mental health outcomes in cancer survivors, the present study was designed with the following objectives.

3.1. Longitudinal Program Effects. Objective 1a: to examine changes longitudinally, before and after a yoga program and at three- and six-month follow-ups, in measures of mood disturbance (primary outcome), stress symptoms, and HRQL as well as proposed predictor variables, including affect and mindfulness. Objective 1b: to examine whether improvements in mood disturbance, stress symptoms and HRQL were associated with concurrent changes in proposed predictor variables, including affect and mindfulness.

3.2. Yoga Practice Maintenance. Objective 2a: to examine whether participants maintain their yoga practice longitudinally, before and after a yoga program and at three- and six-month follow-ups. Objective 2b: to examine whether maintenance of yoga practice was associated with mood disturbance, stress symptoms and HRQL as well as proposed predictor variables, including affect and mindfulness.

4. Methods

4.1. Participants. Ethical approval was obtained from the Conjoint Health Research Ethics Board of the University of Calgary/Alberta Health Services. Program participants were comprised of a heterogeneous group of cancer survivors enrolled in the ongoing “Yoga Thrive: Therapeutic Yoga for Cancer Survivors” program. Participants were eligible for study inclusion if they were (1) aged 18 years or older and (2) had received a cancer diagnosis at any time in the past. Previous participation in the Yoga Thrive program was not an exclusion criterion but was evaluated as part of the study. Participants were informed of the research study at the time of class registration, either via telephone or online. Those that indicated interest in participating in the research study were contacted by the study coordinator. Baseline, postprogram, three- and six-month follow-up surveys were completed online.

4.2. Program. The Yoga Thrive program is a research-based, therapeutic yoga program for cancer survivors and their support persons. This gentle seven-week yoga program is based on contemporary yoga practices modified for cancer survivors. Details of the program have been previously described [40, 41]. The DVD “Yoga Thrive: Therapeutic Yoga for Cancer Survivors” also includes the entire 7-week program. A typical 75-minute class was as follows.

0–10 minutes: gentle breathing and movement, laying supine, with legs flexed at the hip and supported by a wall.

10–60 minutes: 6–10 modified yoga postures/sequences consisting of gentle stretching and strengthening exercises with attention to breath and bodily sensations. Participants progressed from a series of sitting and kneeling postures to standing postures, including stronger postures, balance work and forward bends, before returning to the floor for a series of supine postures.

60–75 minutes: guided supine meditation with attention placed on both breathing and bodily sensations. The yoga classes became progressively more challenging over the seven-week course.

4.3. Recruitment. Power calculations were carried out using GPower 3.1[42]. The sample size/power calculation was based on a clinically significant [43] change in score before-after program on the Profile of Mood States (POMS) Total Mood Disturbance (TMD) score as the primary outcome (Cohen’s $d = .50$). With an $\alpha$ of .05 and power of .80, a minimum
of 34 participants were to be recruited from the Yoga Thrive program.

4.4. Instruments

4.4.1. Baseline

(1) Demographics. Demographic information included self-reported age, education, marital status, and current employment status. Medical history included self-reported cancer diagnosis, date of diagnosis and type(s) of cancer treatment.

(2) Beliefs about Yoga Scale (BAYS). The BAYS [44] is an 11-item self-report measure developed to examine common positive and negative beliefs about yoga in order to help understand participant expectations related to yoga (baseline \( \alpha = .78 \)).

4.4.2. Longitudinal Effects (Objectives 1a and 1b)

(1) Godin Leisure Time Exercise Questionnaire (GLTEQ). The GLTEQ [45] was used to assess physical activity levels. The Leisure Score Index (LSI) subscale of the GLTEQ contains three questions that assess the frequency of mild, moderate, and strenuous physical activity performed for at least 15 minutes duration in a typical week within the past month. In addition, a weekly total of moderate-to-vigorous physical activity can be computed from the GLTEQ (baseline \( \alpha = .88 \); moderate-to-vigorous physical activity = .86).

(2) Activation–Deactivation Adjective Check List (AD ACL). The AD ACL [46] is a 20-item measure that has been utilized previously to map the four quadrants of circumplex affective space [47]. The energy pole is theorized to map the high-activation pleasure quadrant of the circumplex, tension maps the high-activation displeasure quadrant, tiredness maps the low-activation displeasure quadrant, and calmness maps the low-activation pleasure quadrant [26] (baseline \( \alpha: \) energy = .88; tension = .79; tiredness = .84; calmness = .80).

(3) Five-Facet Mindfulness Questionnaire (FFMQ). The FFMQ [48] is a 39-item scale designed to measure five factors that represent elements of trait mindfulness as it is currently conceptualized. The five facets are observing, describing, acting with awareness, nonjudging of, and nonreaction to inner experience. Higher scores indicate higher levels of mindfulness (baseline \( \alpha: \) observing = .85; describing = .87; acting with awareness = .89; nonjudgment = .91; nonreaction = .88).

(4) Profile of Mood States-Short Form (POMS-SF). The abbreviated POMS-SF [49] is a 37-item scale designed to assess six distinct mood states (tension, depression, anger, vigor, fatigue, and confusion) over a one-week period. The instrument also provides a total mood disturbance score by summing the five negative mood state scores and subtracting the one positive score (vigor). Only the POMS-SF total score was used.

(5) Calgary Symptoms of Stress Inventory (C-SOSI). The abbreviated C-SOSI [50] is a 56-item scale designed to assess physical, psychological, and behavioral responses to stressful situations. The instrument provides a total stress score as well as eight subscale scores (depression, anger, muscle tension, cardiolungary arousal, sympathetic arousal, neurological/GI, cognitive disorganization, and upper respiratory symptoms). Higher scores indicate higher reported levels of stress symptoms. Only the C-SOSI total stress score was used.

(6) Functional Assessment of Cancer Therapy-General Version (FACT-G). FACT-G (version 4) [51] is a 27-item questionnaire that measures HRQL. The instrument provides a total HRQL score as well as four subscale scores (physical, social, emotional, and functional). Higher scores indicate higher reported HRQL. Only the FACT-G total score was used.

4.4.3. Yoga Practice Maintenance (Objectives 2a and 2b). Participants were asked to report weekly frequency of ongoing yoga practice via the Yoga Thrive program, community-based yoga programs, home yoga practice or combinations thereof.

4.5. Data Analysis. All data analyses were conducted using IBM SPSS version 19. Demographics and medical history were described using frequency and descriptive statistics to characterize study participants. Statistical analyses were conducted on the entire sample from baseline \( (N = 66) \).

4.5.1. Longitudinal Effects (Objectives 1a and 1b). Multilevel modeling provides a powerful, flexible framework for analyzing nested data structures longitudinally and how change over time in one variable may be related to change over time in other variables [52]. Put in another way, multilevel models allow estimation of both growth and assessment of predictors of differences in that growth for any given outcome of interest. Multilevel models are appropriate for analyzing data with dependent observations (such as within-subject repeated measures) [53]. In addition, multilevel models accommodate all available data, retaining cases for which missing data are present, and provide a valid analysis when data are assumed missing at random [54]. This inclusion of all available data is particularly useful when conducting intention-to-treat (ITT) analyses [55].

In the current analyses two sets of multilevel models were employed. Firstly, estimated marginal means models were created to assess overall change in outcome, predictor, and continuous covariates longitudinally, pre-post and at three- and six-month follow-ups (objective 1a). Secondly, multilevel regression analyses were conducted to assess concurrent associations over time between mood disturbance, stress symptoms and HRQL, proposed predictor variables including affect and mindfulness, and covariates including demographics, time since cancer diagnosis, physical activity, beliefs about yoga, previous yoga experience, and yoga program attendance (objective 1b). Correlations among observations from the same individual were modeled using an unstructured covariance matrix across all time points. By fitting each individual growth trajectory to a specific parametric model,
the overall trajectory of the study sample was obtained and allowed for further investigation of whether differences in growth parameters were related to other predictor variables [56].

In each multilevel regression model, time was measured continuously and included linear, quadratic, and cubic terms as appropriate [56]. The time variable was centered at initial status; therefore the intercept of the regression model was interpreted as participant reports of the outcome variable at baseline. To enhance interpretability of model intercept parameters, all predictor variables were grand-mean centered to allow for inference of average predictor effects [57]. Relationships between predictor and outcome variables were assumed to be constant throughout the study if interaction terms were not significant.

All models were tested step by step. An initial unconditional model was developed for each outcome variable, followed by unconditional growth models. Based on these growth models, predictor variables were tested individually for main effects and for interaction effects with each time term. Significant predictors and their time interactions, if significant, were then tested together as part of their respective overall scale. A final trimmed conditional growth model was developed by entering all significant predictors and their interactions to test overall prediction of outcome variables across time (exclusion \( P > .1 \)). This method of model development has proven robust with smaller sample sizes and ensures these models do not tax the “carrying-capacity” of the dataset [58].

(1) Clinical Significance (Objectives 1a and 1b). In the estimated marginal means models (objective 1a), clinical significance, a marker of program effectiveness, was calculated using Cohen’s \( d \), a distribution-based method, for each outcome variable between baseline and (a) postprogram (8 weeks), (b) three-month, and (c) six-month follow-up \((T_x - T_1)/T_1 SE = \sqrt{N}/\) . These effects were interpreted using Cohen’s interpretation of .20 as a small effect , .50 as a moderate effect and .80 as a large effect [59]. In the multilevel regression analyses (objective 1b), pseudo \( R^2 \) statistics for each model were calculated as unconditional model residual variance – trimmed model residual variance/unconditional model residual variance. These statistics indicate the proportional reduction in residual variance (error) between the unconditional and trimmed model and provide an estimate of effect size similar to traditional ordinary least squares (OLS) regression [60]. These effects can be interpreted using Cohen’s criteria of .02 as a small effect , .13 as a moderate effect and .26 as a large effect [59].

4.5.2. Yoga Practice Maintenance (Objectives 2a and 2b). Associations of predictor and outcome variables with program maintenance (ongoing yoga participation in either the yoga program for cancer survivors, community-based yoga programming, or engaging in home practice) were assessed via logistic generalized estimating equations (GEE) [61]. In this context, GEE take into consideration the within-subject relationships between predictor and outcome variables. Yoga maintenance was dichotomized as either 0—no yoga or 1—ongoing yoga. To determine whether there was a difference between those who practiced yoga and those who did not at each time point, an initial estimated marginal means model with no predictors was run (objective 2a). Logistic GEE were then run to determine associations between yoga practice and predictor variables (objective 2b). Covariates for demographics, time since diagnosis, beliefs about yoga, previous yoga experience and yoga program attendance were entered individually as main effects, followed by physical activity, affect, mindfulness and health outcomes. A final trimmed model was developed by entering all significant predictors and their interactions to test overall prediction of yoga practice maintenance across time (exclusion \( P > .1 \)).

5. Results

5.1. Demographics. 70 participants were eligible for the current study and 66 completed baseline measures used in the current analyses (see Figure 2). The average participant was approximately 53 years of age. The study sample was 90% female. The sample was comprised primarily of participants who had received a breast cancer diagnosis (62.1%). The two other most common diagnoses were lymphoma (10.6%) and colorectal (7.6%). The majority of participants had been diagnosed stages II-III (59.1%) approximately two years prior to study enrollment. Most participants were married (66.7%), highly educated (54.5% had completed university/college), and affluent (60.6% had a combined household income >$80,000 per annum). Many participants (39.4%) had returned to work fulltime. Participants attended an average of five of the seven yoga sessions (see Table 1).

5.2. Longitudinal Program Effects (Objectives 1a and 1b). Estimated marginal means models were computed for covariates including age, time since diagnosis, physical activity, and previous yoga experience, predictor variables including affect and mindfulness, and outcome variables including mood disturbance, stress symptoms, and HRQL (objective 1a).

5.2.1. Covariate Predictors. Participants had already completed Yoga Thrive 1.46 times prior to study enrollment. Most participants reported completing the Yoga Thrive program at eight-weeks, and had completed the program an additional time by the six month follow-up \( F(3,147.14) = 74.32, P < .001 \). Small significant increases from baseline in moderate-vigorous PA were observed at the three- and six-month follow-ups. A small significant increase in total physical activity (LSI) was also observed over time \( F(3,143.52) = 3.28, P = .023 \) (see Table 2).

5.2.2. Affect. Small increases in energy were observed post-program that became more pronounced at the three- and six-month follow-ups \( F(3,148.73) = 11.98, P < .001 \). Small decreases in tiredness after-program were not maintained at the 3-month follow-up but again improved at the 6-month follow-up \( F(3,151.01) = 5.99, P < .001 \). Small decreases
Participants at baseline

Participants after-program

Participants at 3-month follow-up

Participants at 6-month follow-up

Total program participants

Participants interested in study

Eligible participants

| Table 1: Demographics. |    |
|-------------------------|----|
| Baseline (N = 66)       |    |
| Age, years (SD)         | 52.88 (8.11) |
| Time since diagnosis, months (SD) | 23.93 (21.93) |
| Program attendance, number of sessions (SD) | 5.08 (1.94) |
| Cancer diagnosis: breast |    |
| Breast                  | 41 (62.1%) |
| Lymphoma                | 7 (10.6%)  |
| Colorectal              | 5 (7.6%)   |
| Cancer stage            |    |
| II                      | 22 (33.3%) |
| III                     | 17 (25.8%) |
| Gender: female          | 60 (90.9%) |
| Marital status: married/common-law | 44 (66.7%) |
| Education level: completed university/college | 36 (54.5%) |
| Annual household income: >$80,000 | 40 (60.6%) |
| Employment status: full time | 26 (39.4%) |

in tension were observed after-program, and were not maintained at the three-month follow-up, but again improved at the six-month follow-up [F(3, 145.19) = 4.53, P = .005]. There were no changes in patient-reported calmness over time (see Table 2).

5.2.3. Mindfulness. No changes in participants’ observational skills or ability to describe events in the field of consciousness were observed throughout the program. Moderate increases in participants’ ability to act with awareness were observed after-program that were maintained at the three- and six-month follow-ups [F(3, 138.05) = 9.46, P < .001]. Small increases in participants’ ability to be nonjudgmental of inner experience were observed after-program that were maintained at the three- and six-month follow-up [F(3, 138.92) = 3.74, P = .013]. No significant changes in nonreaction were observed after-program but small significant improvements were observed at the three- and six-month follow-up [F(3, 138.90) = 4.25, P = .007] (see Table 2).

5.2.4. Mood Disturbance, Stress Symptoms and Quality of Life. Decreases in mood disturbance were moderate after program. Reductions in mood disturbance were not maintained at the three-month follow-up but improved to postprogram values at the six-month follow-up [F(3, 139.56) = 5.72, P < .001]. A moderate decrease in stress symptoms was observed from baseline to after program that was maintained at both the three- and six-month follow-ups [F(3, 139.12) = 12.21, P < .001]. A small statistically significant improvement in HRQL was observed after program. However, HRQL significantly improved at the three-month follow-up and was maintained at the six-month follow-up [F(3, 137.33) = 7.93, P < .001] (see Table 2).

Follow-up multilevel regression analyses were conducted to explore the associations between mood disturbance, stress symptoms, and HRQL, predictor variables including affect and mindfulness, and covariates including age, time since diagnosis, physical activity, previous yoga experience, and yoga beliefs (objective lb).

5.2.5. Mood Disturbance. Significant linear, quadratic, and cubic effects were observed for time. Those with more
Table 2: Longitudinal estimated marginal means model.

| Measures                | Baseline (T1, N = 66) | 8-weeks after (T2, n = 53) | 3-month follow-up (T3, n = 48) | 6-month follow-up (T4, n = 45) |
|-------------------------|------------------------|------------------------------|-------------------------------|-------------------------------|
|                         | Mean (SE)              | Mean (SE)                    | Mean (SE)                     | Mean (SE)                     |
| **Outcome variables**   |                        |                              |                              |                              |
| Mood disturbance        |                        |                              |                              |                              |
| POMS-SF total           | 20.20 (2.46)           | 11.58 (2.61)                 | 15.01 (2.67)                  | 11.63 (2.74)                  |
| Stress symptoms         |                        |                              |                              |                              |
| C-SOSI total            | 59.08 (3.10)           | 47.41 (3.26)                 | 46.78 (3.31)                  | 49.11 (3.35)                  |
| Quality of life         |                        |                              |                              |                              |
| FACT-G total            | 73.51 (1.98)           | 76.71 (2.06)                 | 78.97 (2.09)                  | 79.66 (2.12)                  |
| **Predictor variables** |                        |                              |                              |                              |
| Program experience      |                        |                              |                              |                              |
| Enrolment               | 1.46 (0.29)            | 2.45 (0.29)                  | 3.02 (0.30)                   | 3.49 (0.30)                   |
| Physical activity       |                        |                              |                              |                              |
| LSI                     | 21.70 (2.03)           | 23.39 (2.18)                 | 25.39 (2.22)                  | 27.83 (2.26)                  |
| GLTEQ                   | 92.94 (13.64)          | 96.50 (14.52)                | 121.74 (15.27)                | 120.48 (15.48)                |
| Affect                  |                        |                              |                              |                              |
| Energy                  | 9.53 (0.52)            | 10.88 (0.57)                 | 11.86 (0.59)                  | 13.11 (0.60)                  |
| Tiredness               | 11.60 (0.54)           | 10.16 (0.59)                 | 10.62 (0.62)                  | 8.82 (0.63)                   |
| Tension                 | 9.35 (0.43)            | 7.66 (0.47)                  | 8.47 (0.49)                   | 7.99 (0.50)                   |
| Calmness                | 12.77 (0.43)           | 13.77 (0.47)                 | 13.27 (0.49)                  | 13.23 (0.50)                  |
| Mindfulness             |                        |                              |                              |                              |
| Observe                 | 24.92 (0.79)           | 25.81 (0.85)                 | 26.08 (0.87)                  | 27.13 (0.90)                  |
| Describe                | 23.04 (0.85)           | 23.86 (0.90)                 | 23.20 (0.92)                  | 24.12 (0.93)                  |
| Act w/Awareness         | 18.54 (0.69)           | 20.40 (0.73)                 | 20.31 (0.74)                  | 21.23 (0.75)                  |
| Nonjudgment             | 20.35 (0.84)           | 22.47 (0.90)                 | 21.96 (0.92)                  | 22.65 (0.94)                  |
| Nonreaction             | 19.92 (0.63)           | 20.82 (0.67)                 | 21.61 (0.68)                  | 21.51 (0.69)                  |

5.2.6. Stress Symptoms. There were significant linear and quadratic effects of time, indicating an initial decline in stress symptoms that slowed over time. Higher positive beliefs about yoga at baseline were associated with lower stress symptoms. Those who reported higher moderate-to-vigorous PA and a greater ability to act with awareness and be nonreactive to inner experience concurrently reported lower stress symptom scores. Higher tension was significantly associated with higher stress symptoms. The Pseudo $R^2$ value suggests inclusion of these variables reduced error in predicting stress symptoms by 40% (see Table 3).

5.2.7. Quality of Life. A non-significant linear increase in HRQL was observed over time. Higher baseline beliefs about yoga were associated with higher HRQL. Those who reported higher overall PA, energy, and the ability to be nonjudgmental of inner experience reported higher HRQL. Those who reported high levels of tension reported lower levels of HRQL. The Pseudo $R^2$ value suggests inclusion of these predictor variables reduced error in predicting HRQL by 29% (see Table 3).

5.3. Yoga Practice Maintenance (Objectives 2a and 2b). Longitudinal GEE logistic estimated marginal means models were conducted to examine yoga practice before and after the yoga program and at three- and six-month follow-ups (objective 2a). Upon initiation of the current study, 48% (32 participants) reported previous yoga practice experience either through the Yoga Thrive program, community classes, home practice, or combinations thereof. At the end of the seven-week yoga program, 96% were still practicing yoga in various settings, a significant increase of 48% from baseline. At the three-month follow-up yoga practice had dropped, with 69% of participants were still practicing yoga in various settings, a significant 20% increase from baseline. At the six-month follow-up there was a slight increase in participation rates, with 76% of participants reporting continued yoga practice in various settings, a significant 27% increase from baseline (see Table 4).
Table 3: Longitudinal multilevel regression model.

| Predictor | Mood disturbance (POMS-SF total) | Stress symptoms (C-SOSI total) | Quality of life (FACT-G total) |
|-----------|----------------------------------|--------------------------------|--------------------------------|
|           | Est. (SE) df t P                 | Est. (SE) df t P               | Est. (SE) df t P               |
| Intercept | 16.98 (2.10) 76 8.09 .000       | 54.89 (2.40) 69 22.87 .000    | 76.95 (1.49) 60 51.53 .000    |
| Time      | Time 1 | -5.36 (2.22) 91 -2.41 .018   | -3.90 (0.97) 108 -4.04 .000   | 0.27 (0.16) 60 1.65 .104     |
|           | Time 2 | 1.59 (0.74) 86 2.16 .033     | 0.41 (0.11) 90 3.62 .000      | — — — —                     |
|           | Time 3 | -0.12 (0.06) 85 -1.96 .053   | — — — —                      | — — — —                     |
| Predictors| Beliefs about Yoga | -0.57 (0.22) 52 -2.63 .011   | -0.79 (0.27) 50 -2.87 .006    | 0.42 (0.19) 57 2.23 .030     |
|           | Physical activity | Leisure score index | -0.17 (0.08) 161 -2.17 .032   | — — — —                      |
|           |           | Mod.-to-vigorous PA | — — — —                      | — — — —                     |
| Affect    | Energy   | -0.67 (0.34) 178 -1.96 .052   | — — — —                      | 0.44 (0.17) 158 2.62 .010    |
|           | Tension  | — — — —                      | 1.35 (0.33) 158 4.07 .000     | -0.81 (0.19) 150 -4.27 .000  |
|           | Tiredness| 0.75 (0.31) 176 2.45 .015     | — — — —                      | — — — —                     |
| Mindfulness| Act w/awareness | -0.58 (0.25) 144 -2.33 .021   | -0.67 (0.29) 174 -2.29 .023   | — — — —                     |
|           | Nonjudgment| — — — —                      | -0.76 (0.24) 185 -3.20 .002   | 0.56 (0.12) 180 4.71 .000    |
|           | Nonreaction| -0.56 (0.26) 140 -2.13 .035   | — — — —                      | — — — —                     |

Pseudo R²: Mood disturbance = 0.31 Stress symptoms = 0.40 Quality of life = 0.29

Variables excluded (P > .1): age, time since diagnosis, previous Yoga Thrive program experience, current Yoga Thrive class attendance, calmness (ADACL), observe and describe (FFMQ). Est.: estimate, df: degrees of freedom, and P: significance.

Table 4: Yoga practice maintenance estimated marginal means model.

| Measures   | Baseline T1 (N = 66) | 8-weeks after T2 (n = 53) | 3-month follow-up T3 (n = 48) | 6-month follow-up T4 (n = 45) |
|------------|----------------------|---------------------------|-----------------------------|-------------------------------|
|            | Mean (SE)            | Mean (SE)                 | T2 − T1 SMD p d             | Mean (SE)                    | T3 − T1 SMD p d             | Mean (SE)                    | T4 − T1 SMD p d             |
| Adherence  | 0.48 (0.06)          | 0.96 (0.03)               | .000 0.98                   | 0.69 (0.07)                  | .008 0.41                   | 0.76 (0.06)                  | .002 0.55                   |

T: time, SMD: standard mean difference, SE: standard error, P: significance, and d: Cohen’s d.

Follow-up GEE logistic regression analyses were performed to examine what participant characteristics predicted ongoing yoga practice (objective 2b). In examining associations between yoga practice at each time point and predictor variables, there was an initial positive linear effect for time, reflecting the increased rate of participants reporting yoga practice before-after program. The quadratic trend reflects a significant decline postintervention completion in yoga practice at three- and six-months. Those who reported more frequent participation in the Yoga Thrive program at each time had a greater chance of continuing their yoga practice. In addition, those who reported higher energy at each time point were more likely to maintain a yoga practice, as were those who reported a greater ability to be nonreactive to inner experience. Finally, those with higher self-reported HRQL at each time point had a greater chance of continuing yoga practice (see Table 5).

6. Discussion

Despite an emerging body of evidence highlighting the benefits of yoga for cancer survivors, little work has been done to bridge these clinical findings with theoretical predictors of change. The current research sought to bridge this gap between determining clinical benefits and describing predictors of these improvements in mood disturbance, stress symptoms and HRQL. Using the Circumplex Model of Affect as it has been applied in exercise settings [62] and emerging work examining the mechanisms of mindfulness [30, 36, 63] and yoga [64–66], a series of multilevel models were developed to examine (1) longitudinal changes in mood disturbance, stress symptoms and HRQL, predictor variables including affect and mindfulness, and whether these variables predicted change in these outcomes (objectives 1a and 1b); and (2) maintenance of yoga practice and whether maintenance could be anticipated by the aforementioned outcome and predictor variables (objectives 2a and 2b).

6.1. Longitudinal Program Effects (Objectives 1a and 1b)

6.1.1. Affect. Current study results suggest a linear increase in energy over time. These findings concur with research in the area of aerobic training [18] which suggest positive improvements in high-activation positive affect (e.g., energy) over time when exercise is of lower intensity and duration. Given
the burden of fatigue in cancer survivors, improvements in energy are important and corroborate corollary improvements in fatigue indices in both the exercise and cancer [67–69], mindfulness [70, 71] and yoga literature [9].

6.1.2. Mindfulness. Longitudinal findings suggest participants reported improved ability to act with awareness, a mindfulness facet closely related to one’s ability to concentrate [36]. Participants also reported increased nonjudging of inner experience, the taking of an impartial stance to thoughts and feelings, and nonreaction to inner experience, the ability to let thoughts and emotions come and go without having to act upon them. Research suggests the mindfulness facets of acting with awareness, nonjudgment, and nonreaction are most closely tied to decreased psychological distress [48]. Similar improvements in these mindfulness facets were also reported by Garland et al. [39] and Bränström et al. [37, 38] although effects reported in these other studies were of a larger magnitude and included improvements in the other facets of mindfulness as well. One potential explanation is that yoga practice may differ from formal mindfulness meditation training in preferentially developing skills of acting with awareness, nonjudging, and nonreactivity but not similarly help to develop other mindfulness skills of observing and describing one’s experience.

6.1.3. Mood Disturbance, Stress Symptoms, and Quality of Life. Baseline positive yoga beliefs were consistently associated with lower mood disturbance, stress symptoms, and higher HRQL at all time points. Sohl et al. [44] suggest baseline yoga beliefs are intrinsic to both initial yoga program engagement and reported health outcomes. This speaks to the importance of patient preferences in choosing treatments and the role that positive expectancies play in driving improvements [72]. In addition, those who reported higher physical activity concurrently reported lower mood disturbance, stress symptoms and higher HRQL at all time-points. These findings reflect research suggesting the effects of exercise on mental health and HRQL in cancer survivors [67, 73].

The present research ascribed to Russell’s (2003) thesis that when affective dimensions are examined longitudinally, they are no longer tied to a specific context as in acute exercise settings, where the temporal proximity to an exercise session is evident. Rather, these measures become reflective of what Russell (2003) has termed prolonged, objectless core affect [25]. It could be argued that including both the POMS-SF and ADACL created measurement redundancies, as both include items that tap the construct of mood. However, the two measures are fundamentally different from a conceptual standpoint. The POMS-SF has been used to measure mood reflecting discrete, largely negative, mood states. On the other hand, the ADACL has been used to tap the two basic affective dimensions of valence and activation, which, when combined, can theoretically provide a representation of the entire affective domain, including positive and negative, as well as high- and low-activation variants of affective experience. Given that yoga theoretically may generate a range of affective states, including both low-activation pleasure (calmness) and high-activation pleasure (energy), and given that cancer survivors experience both low-activation displeasure (tiredness) and high-activation displeasure (tension), it behooves researchers to utilize measures that capture the full range of affective experiences. Furthermore, dimensional measures of affective states may constitute more categorical mood states, including the mood states captured by the POMS-SF [15, 74, 75].

Higher reported ability to act with awareness was associated with lower mood disturbance and stress symptoms at all times. Higher reported nonjudgment of inner experiences was related to lower stress symptoms and higher HRQL. These improvements may reflect an accepting attention strategy in which participants find alternate ways to respond to stressful situations [30]. These findings are similar to the study by Garland et al. [39], in which both acting with awareness and being nonjudgmental of inner experience were correlated with reduced stress and mood disturbance. Higher non-reactivity to inner experience was related to lower mood disturbance. Research with experienced meditators and non-meditators suggests the ability to be nonreactive to inner experience is highly related to meditation experience and is most likely to mediate psychological health outcomes [76]. The present research is congruent with previous work suggesting yoga’s effectiveness in reducing psychological distress and improving HRQL in cancer survivors [7, 9]. Continued significant changes in all three measured health outcomes were observed, despite the fact that 48% of participants at baseline were already yoga practitioners and had arguably already derived initial program benefits. Findings suggest improvements in health outcomes are associated with beliefs

| Parameter                                      | B (SE)   | Wald χ² | Odds ratio (95% CI) | P     |
|------------------------------------------------|---------|---------|---------------------|-------|
| (Intercept)                                    | 1.50 (0.38) | 15.77   | 4.50 (2.14, 9.45)   | .000  |
| Time                                           | 0.63 (0.23) | 7.11    | 1.87 (1.18, 2.96)   | .008  |
| Time²                                          | −0.09 (0.03) | 10.83   | 0.91 (0.86, 0.96)   | .001  |
| Previous participation in yoga thrive          | 0.63 (0.22) | 8.42    | 1.88 (1.23, 2.87)   | .004  |
| Energy                                         | 0.13 (0.06) | 4.94    | 1.14 (1.02, 1.27)   | .026  |
| Nonreaction to inner experience                | 0.08 (0.03) | 5.86    | 1.08 (1.02, 1.16)   | .015  |
| Quality of life                                | 0.03 (0.01) | 4.23    | 1.03 (1.00, 1.06)   | .040  |

Excluded variables (P > .1): age, time since diagnosis, yoga beliefs, attendance, physical activity, tension, tiredness, calmness (ADACL), observe, describe, act with awareness, nonjudgment (FFMQ), mood disturbance (POMS-SF), and stress symptoms (C-SOSI). B: estimate, SE: standard error, and P: significance.
about yoga, physical activity, affective dimensions of energy, tension and tiredness, and facets of mindfulness, including the ability to act with awareness, be nonjudgmental of and nonreactive to inner experience. Associations between positive affective states and mindfulness are becoming clearer as state and trait measures of both constructs have been found to be highly related [29].

6.2. Yoga Practice Maintenance (Objectives 2a and 2b). Previous participation in the Yoga Thrive program was a significant predictor of yoga practice maintenance at all time points. This finding is similar to Speed-Andrews and colleagues’ finding that yoga experience over the past year was significantly related to current yoga adherence in a cancer setting [77]. Positive experiences and increased well-being derived from yoga classes are suggested mechanisms for this increased program adherence [78].

Those reporting higher energy at each time point were also more likely to continue yoga practice. This relationship between positive affect and adherence has been widely reported in the literature [18, 19]. It is hypothesized the positive appraisal of physical activity as pleasurable is likely to bolster participant self-efficacy and lead to increased adherence and maintenance [79]. Recent American College of Sports Medicine (ACSM) guidelines also suggest positive affect may be an important determinant of exercise adherence [80].

Results suggesting those higher in non-reactivity were more likely to adhere to yoga practice are also supported in the literature. Nonreaction refers specifically to the ability to remain calm in the face of distressing thoughts and emotions. This ability to be nonreactive to inner experience has salutary effects and seems to be a key facet of mindfulness as well as one of the facets most affected by contemplative training [76]. Research by Ulmer and colleagues [81] suggests those with higher mindfulness scores are less reactive and better able to accurately appraise and respond to stressors that may impact routine activities, including yoga practice.

Results from the current study suggest a reciprocal relationship in which higher HRQL is associated with yoga practice maintenance. Higher HRQL has been associated with increasing individual self-efficacy to adhere and maintain exercise programs [79]. Maintenance of pre-cancer diagnosis physical activity levels and bodyweight is associated with better HRQL after breast cancer [82] and those who report meeting physical activity requirements in general report higher HRQL across cancer diagnoses [83].

Taken together these results suggest previous yoga experience coupled with higher energy, a greater ability to be nonreactive to inner experience and higher HRQL interact to improve the likelihood participants will maintain yoga practice, arguably further engendering the benefits of these practices. If affect and mindfulness are both associated with improved mental health outcomes and HRQL and cited as leading to increased program adherence, it behooves clinicians to consider developing approaches that focus more exclusively on the inherent psychological benefits of exercise, including yoga [62, 80].

6.3. Limitations. The use of an observational research design, including 48% of study participants who had already completed the program, added complexity to the current analyses. Without a comparison group, it is impossible to determine whether positive program effects were related to the yoga program, or due to the simple passage of time, among other factors. Also, given the high degree of previous yoga experience within the study sample, these findings are not generalizable to a general cancer survivor population. Despite these limitations, a comparison group was not utilized. Rather, the researchers elected to conduct the research in a “real-world” clinical setting given the Yoga Thrive programs’ broad community-based implementation and the researchers’ stated goal of identifying and developing theory to examine likely predictors of change in participant-reported outcomes [14]. However, as yoga program specific predictors of change are posited, subsequent research designs should include comparative effectiveness studies in which pragmatic trials use real-world comparison conditions rather than attention or waitlist controls using uniformly yoga naïve participants [84]. An additional limitation of the current study is the lack of a measure of home practice. Current work by Ross et al. [85] suggests the addition of home practice predicts mindfulness, subjective well-being, fatigue, sleep, and a variety of behavioral outcomes. In addition, frequency of yoga home practice was a better predictor of health than either total years of practice or class frequency. Given these findings, the thorough assessment of yoga practice outside of class time is imperative. Additional limitations include the self-report nature of all outcomes. While distribution-based markers of clinical significance have been introduced for these outcomes, future research would be better served by including more objective anchor-based methodology as well as supportive biomarkers of change [86]. While the study was powered on detecting a 0.50 difference on the POMS in the estimated marginal means models it was not powered for the multilevel regression analyses. However, research suggests samples of 50 study participants may be sufficient and show little bias in the regression coefficients [87]. In addition, no corrections were made for multiple comparisons. Therefore, care must be exercised in the interpretation of statistical significance due to the potential for false-positive (Type I error) findings.

7. Conclusion

Before yoga can be broadly applied within oncology, carefully designed and executed research that convincingly evaluates not only the effectiveness of yoga in clinical settings but also posits potential predictors of program outcomes are required. Despite the aforementioned limitations, longitudinal multilevel analyses allowed for the integration of theory to develop a novel research design able to examine mental health outcomes, contextual factors, and interactions thereof, within an existing community-based yoga program for cancer survivors. This combined knowledge can be translated directly back into the community to further develop innovative yoga programs and best practices with the express aim of
improving mental health and HRQL in cancer survivors, soothing both mind and body.

Acknowledgments

The authors would like to thank all the study participants and yoga teachers involved in this research. They thank Gisela Engels (University of Calgary) for her statistical support. They would also like to thank Laura Labelle, PhD (Tom Baker Cancer Centre), and Sheila Garland, PhD (Perelman School of Medicine), for their editorial contributions to this paper. Michael J. Mackenzie acknowledges Social Sciences and Humanities Research Council of Canada (SSHRC) and Alberta Innovates-Health Solutions (AIHS) for funding his doctoral program of research.

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Research Article

Cardiovascular and Respiratory Effect of Yogic Slow Breathing in the Yoga Beginner: What Is the Best Approach?

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Received 18 December 2012; Accepted 22 March 2013

Academic Editor: Elisa Harumi Kozasa

Slow breathing increases cardiac-vagal baroreflex sensitivity (BRS), improves oxygen saturation, lowers blood pressure, and reduces anxiety. Within the yoga tradition slow breathing is often paired with a contraction of the glottis muscles. This resistance breath “ujjayi” is performed at various rates and ratios of inspiration/expiration. To test whether ujjayi had additional positive effects to slow breathing, we compared BRS and ventilatory control under different breathing patterns (equal/unequal inspiration/expiration at 6 breath/min, with/without ujjayi), in 17 yoga-naive young healthy participants. BRS increased with slow breathing techniques with or without expiratory ujjayi ($P < 0.05$ or higher) except with inspiratory + expiratory ujjayi. The maximal increase in BRS and decrease in blood pressure were found in slow breathing with equal inspiration and expiration. This corresponded with a significant improvement in oxygen saturation without increase in heart rate and ventilation. Ujjayi showed similar increase in oxygen saturation but slightly lesser improvement in baroreflex sensitivity with no change in blood pressure. The slow breathing with equal inspiration and expiration seems the best technique for improving baroreflex sensitivity in yoga-naive subjects. The effects of ujjayi seems dependent on increased intrathoracic pressure that requires greater effort than normal slow breathing.

1. Introduction

Respiratory research documents that reduced breathing rate, hovering around 5-6 breaths per minute in the average adult, can increase vagal activation leading to reduction in sympathetic activation, increased cardiac-vagal baroreflex sensitivity (BRS), and increased parasympathetic activation all of which correlated with mental and physical health [1–4]. BRS is a measure of the heart’s capacity to efficiently alter and regulate blood pressure in accordance with the requirements of a given situation. A high degree of BRS is thus a good marker of cardiac health [5].

The slow breathing-induced increase in BRS could be due to the increased tidal volume that stimulates the Hering-Breuer reflex, an inhibitory reflex triggered by stretch receptors in the lungs that feed to the vagus [6]. In addition, the slow breathing increases the oxygen absorption that follows greater tidal volume ($V_t$), as a result of reduction in the effects of anatomical and physiological dead space [7, 8]. This might in turn produce another positive effect, that is, a reduction in the need of breathing. Indeed, a reduction in chemoreflex sensitivity and, via their reciprocal relationships, an increase in BRS, have been documented with slow breathing [9–13].

Ujjayi resistance breathing, a breathing practice taught by the yogic tradition, reduces airflow, and during expiration it increases the intrathoracic pressure due to a slight contraction of the glottis muscles, potentially resulting in intensified vagal activity [14–16]. The increase in expiratory intrathoracic pressure should also enhance oxygen absorption above what is found in slow breathing, potentially elevating blood pressure levels more than with slow breathing alone and inducing greater BRS [17]. Lastly, ujjayi breathing facilitates greater control over airflow and, therefore, breath rate [14]. Consequently, ujjayi may be a more effective method...
than slow breathing on its own as a means to achieve five breaths per minute for the average person who tends to breathe at 12–18 breaths per minute. On the other hand, the additional effort to exhale, induced by the increased intra-thoracic pressure, might stimulate sympathetic activity, partially reducing the advantages of this technique. Accordingly, we tested whether ujjayi breath would improve oxygen saturation and BRS, more than slow breathing alone.

2. Materials and Methods

2.1. Subjects. The protocol of this study was approved by the Ethics Committee of the University of Pavia, Italy, and all participants gave informed consent to participate in this study. Using a within-participants design, 17 young healthy participants were recruited by word of mouth through university students and staff. Participants provided information pertaining to their general level of fitness, level of sport undertaken (including specialties that lead to practices similar to yoga like diving and martial arts), smoking habits, and average alcohol consumption. These and the anthropometric characteristics of the subjects are shown in Table 1.

2.2. Protocol. The electrocardiogram was recorded using a bipolar precordial lead. Continuous blood pressure was monitored with a digital plethysmograph (Portapres, FMS Medical Systems, Amsterdam, The Netherlands) from the middle finger of the right arm held at heart level. Two respiratory signals were obtained by inductive plethysmography, from belts positioned around the chest and the abdomen. Pulse oximetry and expired carbon dioxide partial pressure (Cosmo, Novametrix, Wallingford, CT, USA) were also obtained.

Pretesting, participants spent approximately 10 minutes learning how to engage ujjayi breath with a qualified yoga teacher. They were then connected to the measuring devices ready for testing. The testing phase comprised 7 conditions distinguished by breathing rate and inclusion or not of ujjayi breath. Although the effects described for ujjayi should essentially occur during expiration (as normally practiced), we also included an evaluation of ujjayi during both inspiration and expiration, as suggested by some yoga teachers. We decided to perform the ujjayi without the addition of so-called “bandhas” (i.e., contractions at the level of perineum or abdomen or tucking the chin close to the chest), since in yoga naïve participants these additional movements could be difficult to perform without practice. This is also in agreement with many yoga schools, which do not necessarily associate the bandhas with ujjayi. The recordings were made in the supine position during 3 minutes spontaneous breathing, during 2 minutes controlled breathing at a frequency similar to normal spontaneous breathing (15 breaths/minute), and during 2 minute periods of slow deep breathing at the rate of 6 cycles/minute with either equal or unequal inspiration/expiration ratio and with or without ujjayi (Table 2 reports the methodology for the different recordings).

All recordings were performed in random order, except baseline that was always performed first. Each recording was separated by the previous one by 2 minutes.

All signals were simultaneously acquired on a personal computer with an analog-to-digital converter with a 12-bit resolution at a sampling rate of 400 Hz on a Macintosh computer using a special software written in our laboratory.

2.3. Assessment of BRS. From the original data the time series of RR interval (from each of 2 consecutive R waves of the electrocardiogram) and systolic blood pressure (SBP) were obtained. Previous studies have shown a poor correlation between different indices of BRS, while on the other hand, no method has shown clear superior performance over the other [18]. Accordingly, we computed a set of 7 different tests and used their average [19]. BRS was determined from spontaneous fluctuations in the RR interval and SBP during the spontaneous, 15/min and 6/min recordings using the positive and negative sequence methods [20], the alpha coefficient in the low and high frequency bands and its average [21], and the transfer function technique [22]. In the sequence methods, the BRS was estimated by identifying spontaneously occurring sequences of 3 or more consecutive heartbeats in which both the SBP and the subsequent RR intervals changed in the same direction. The minimum criteria for change were 1 mm Hg for SBP and 5 ms for the RR intervals. For identified positive and negative sequences with a correlation coefficient between the RR intervals and the SBP exceeding 0.85, the regression slopes (the slope of the regression line between SBP and RR intervals) were calculated, and the average was taken as a measure of BRS positive and negative slopes, respectively. The other 4 BRS methods were calculated by autoregressive uni- and bivariate spectral analysis. The alpha coefficient was calculated as the square root of the ratio of the powers of RR intervals and SBP in the low frequency range (0.04–0.15 Hz) and in the respiratory (0.15–0.40 Hz) high frequency range when coherence was greater than 0.5, and the phase difference between SBP and RR intervals was negative. In the transfer function method BRS was calculated as the average value of SBP-RR cross-spectrum divided by the SBP spectrum in the low frequency range (0.04–0.15 Hz), when coherence exceeded 0.5. The last method was obtained by the standard deviation of RR interval divided by the standard deviation of SBP after a high-pass filtering at 0.050 Hz corner frequency, 6 dB/octave attenuation, as recently proposed and validated [19].

Table 1: Characteristics of the participants (mean ± SEM).

| Parameter                                | Value     |
|------------------------------------------|-----------|
| Number                                    | 17        |
| Sex (men/women)                          | 8/9       |
| Age (years)                              | 27.2 ± 1.1|
| Weight (kg)                              | 63.4 ± 3.3|
| Height (m)                               | 1.72 ± 2.5|
| Body mass index (kg/m²)                  | 21.1 ± 0.6|
| Training sessions frequency per week     | 2.6 ± 0.3 |
| Energy expenditure per week (mets)       | 14.6 ± 2.1|
| Smokers                                  | 0.0 ± 0.0 |
| Alcohol (glasses/week)                   | 2.2 ± 0.5 |
| Diving and martial arts practitioners    | 0.0 ± 0.0 |
Table 2: Conditions tested.

| Breath rate                          | Ujjayi/no ujjayi                      |
|--------------------------------------|---------------------------------------|
| (1) Spontaneous—baseline measure     | No ujjayi                             |
| (2) Fast breathing—15 per minute, 2 second inspiration and expiration | No ujjayi |
| (3) Slow breathing—6 per minute, 5 second inspiration and expiration | No ujjayi |
| (4) Slow breathing—6 per minute, 5 second inspiration and expiration | No ujjayi |
| (5) Slow breathing—6 per minute, 5 second inspiration and expiration | Ujjayi |
| (6) Slow breathing—6 per minute, 3 second inspiration/7 second expiration | No ujjayi |
| (7) Slow breathing—6 per minute, 3 second inspiration/7 second expiration | Ujjayi on exhalation only |

2.4. Analysis of Respiration. The signals from the inductive plethysmographic belt signals were analyzed by an interactive program to identify for each breath the positive and negative respiratory peaks, together with the respiratory period. The sum of the signals obtained by the 2 belts was taken as a relative index of tidal volume. Additionally, the same program automatically identified the end-expiratory (end-tidal) value in the carbon dioxide signal. Using the inductive belt data a semiquantitative intrasubject analysis of ventilation could be obtained, by comparing the relative changes in \( V_t \) and minute ventilation \( (V_{E}) \) induced by oxygen inhalation or different breathing patterns. Although the device used for the present study does not allow to obtain \( V_t \) and minute ventilation in absolute values (mL and L/min, resp.), we took advantage of the strong linear relationship between \( V_t \) and the inductive belt signals [23], thus allowing us to obtain ventilation in relative units. Great care was taken to ascertain that the belts would not be displaced during the experiment. The limitation of the semiquantitative analysis is compensated by the lack of interference with the spontaneous breathing, that typically occurs with mouthpieces [24]. We therefore set the minute ventilation obtained during spontaneous breathing (our baseline) as 100% in each subject and calculated the minute \( V_E \) or \( V_t \) in % changes from that value for each recording [25].

2.5. Estimates of Chemoreflex Sensitivity. Although it was practically impossible to practice this type of respiration during a typical chemoreflex testing (requiring a rebreathing circuit and a mouthpiece or a face mask) [11], we could still use a previously validated simpler and approximative index of chemoreflex sensitivity, based on the ratio of tidal volume to inspiratory time \( (V_t/T_i) \) [26]. Because we evaluated the \( V_t \) only in relative units, we used the same normalisation procedure used for ventilation data and thus expressed the values obtained in each recording as variations from the baseline (set to 100% in each subject).

2.6. Statistical Analysis. Data are presented as mean ± standard error of the mean (SEM). Statistical differences between baseline and the different interventions (6/min versus 15/min controlled breathings) were tested by analysis of variance for repeated measures (ANOVA) [27]. Sheffe’s test was used to test for significances between different breathing techniques. Statistical significance was defined as a value ≤0.05. All comparisons were done with respect to spontaneous breathing and also with controlled breathing at a frequency similar to the spontaneous (15 breath/min), to identify the effect of controlling respiration per se.

3. Results

Complete results are shown in Table 3 and Figures 1 and 2. Overall, data were consistent, and we did not find significant differences between male and female participants.

3.1. BRS (Figure 1). In comparison to spontaneous breathing, fast breathing led to a reduction in BRS, whilst all slow breathing (with or without ujjayi breathing) increased BRS. This increase was seen in both the symmetrical (5 second inspiration and expiration) and asymmetrical (3 second inspiration and 7 second expiration) slow breathing conditions. Engaging ujjayi breathing on the exhalation had the effect of reducing the increase in BRS of slow breathing alone, and this was further reduced with ujjayi on the inspiration and expiration (which was not significantly higher than baseline). These differences were even more pronounced with respect to controlled breathing at 15 breath/minute, which also showed highly significant differences with respect to spontaneous breathing, but in the opposite direction.
Table 3: Effects of respiratory patterns on cardiorespiratory variables.

| Variable                        | Spontaneous | 15/min | 6/min (3 s inspiration + 7 s expiration) | 6/min (5 s inspiration + 5 s expiration) |
|---------------------------------|-------------|--------|----------------------------------------|----------------------------------------|
|                                 | No ujjayi   | No ujjayi | No ujjayi | Ujjayi exp | No ujjayi | Ujjayi exp | Ujjayi ins + exp |
| RR interval (ms)                | 830 ± 32    | 769 ± 26*** | 802 ± 25†  | 789 ± 24†  | 832 ± 26*** | 809 ± 25†  | 797 ± 20***     |
| Systolic blood pressure (mmHg)  | 121.84 ± 5.67 | 113.96 ± 5.67* | 117.91 ± 5.21 | 120.06 ± 4.58 | 111.34 ± 4.91*** | 118.46 ± 4.77* | 116.25 ± 4.97†  |
| Diastolic blood pressure (mmHg) | 54.78 ± 3.69 | 51.93 ± 2.88* | 53.99 ± 3.14 | 55.77 ± 3.01 | 55.14 ± 3.23* | 54.55 ± 3.29* | 54.28 ± 2.91†  |
| Oxygen saturation (%)           | 98.37 ± 0.17 | 99.19 ± 0.17*** | 98.90 ± 0.18** | 98.91 ± 0.14** | 98.90 ± 0.19* | 98.95 ± 0.17** | 98.88 ± 0.18*   |
| End-tidal carbon dioxide (mmHg) | 36.26 ± 1.27 | 26.11 ± 0.98*** | 31.14 ± 1.13** | 30.23 ± 0.97*** | 30.24 ± 0.68*** | 29.76 ± 1.22*** | 29.69 ± 0.90*** |
| $V_t$ (normalized to spontaneous breathing) | 100.00 ± 0.00 | 152.82 ± 14.33** | 318.40 ± 28.48*** | 368.48 ± 38.32**** | 249.12 ± 24.39***** | 318.88 ± 34.01***** | 293.91 ± 30.56*** *** | 149.77 ± 14.71** ** |
| $V_E$ (normalized to spontaneous breathing) | 100.00 ± 0.00 | 190.88 ± 17.02*** | 158.81 ± 11.82*** | 183.35 ± 15.33*** | 125.12 ± 9.96*** | 160.69 ± 14.88*** ** | 149.77 ± 14.71** ** |

*P < 0.05; **P < 0.01; ***P < 0.001, versus spontaneous breathing.

†P < 0.05; ‡P < 0.01; §§P < 0.001, versus no ujjayi.

¶P < 0.05; ¶¶P < 0.01; ¶¶¶P < 0.001, versus 6/min (3 s inspiration + 7 s expiration).
As slow breathing showed in general opposite results than 15 breath/minute controlled breathing (Table 3 and Figures 1 and 2), all observed changes were more significant when slow breathing with and without ujjayi was compared to fast breathing for all the variables considered.

### 4. Discussion

The present study found that, in nearly all forms of slow breathing performed in yogic breathing naive participants, there were increased BRS (only slow breathing with ujjayi during inspiration and expiration did not result statistically significant) and oxygen saturation, with reduced blood pressures and chemoreflex sensitivity. The greatest improvement was found in slow breathing without ujjayi, while breathing controlled at a rate of 15/min caused a drop in BRS. In all forms of slow breathing there was a statistically significant increase in oxygen saturation from the mean baseline of 98.3%, confirming the relationship between high levels of oxygen absorption and BRS. However, ujjayi breath showed the greatest saturation (albeit only 0.1–0.2% percent greater), but it did not correspond to the greatest improvement in BRS, likely due to the increased respiratory effort (as seen by the increased heart rate). The increase in BRS was mirrored by a reciprocal drop in chemoreflex estimate. No significant difference was found between asymmetrical versus symmetrical breathing at 6 breaths per minute. These results show that simple slow breathing with equal inspiration/expiration is the best compromise to obtain positive cardiorespiratory effects in yoga naïve subjects.

#### 4.1. Oxygen Absorption and BRS

In this study, we show that slow breathing and increased oxygen absorption lead to enhanced BRS. This might result from several possible factors, all interrelated. In theory, the increase in arterial oxygen partial pressure increases blood pressure, which in turn could stimulate the baroreceptors and improve the BRS gain. This was recently observed in healthy [28] and diabetic subjects [25]. The seemingly small extent of the increase in oxygen saturation should not be overlooked. In fact, the haemoglobin dissociation curves states that at higher saturation values small changes reflex large changes in the partial pressure of oxygen.

Because the oxygen tension (and not oxygen saturation) is the chemoreflex input signal, this explains why in a previous study the administration of oxygen in normoxia induced a significant increase in BRS and parasympathetic activity despite a small increase in oxygen saturation [25]. Thus, the increased oxygen absorption may inhibit the chemoreflex and, by this reciprocal relationship [9, 10], increase BRS. Bernardi et al. (2001) demonstrated that slow breathing reduced chemoreflex sensitivity to both hypoxia and hypercapnia, in part attributing this to an inverse relationship with BRS [11]. It is well understood that the chemoreflex is a mechanism to stabilize blood pH by increasing ventilation. Possibly, the increase in oxygen in ujjayi and slow breathing may inhibit the chemoreflex necessarily stimulating greater BRS. Our findings of the reciprocal BRS and chemoreflex changes are in full support of this concept, within the limitations of
the chemoreflex method adopted. Secondly, slow breathing with its increased $V_{e}$ might induce changes in venous return, altering stroke volume, and enhancing phasic changes in systolic blood pressure, synchronous with breathing, that may in turn enhance BRS [11, 29]. Lastly, a central effect of slow breathing with a direct stimulation of parasympathetic activity could not be excluded. These last factors might explain why in this study the increase in oxygen induced by the slow breathing was associated with a reduction in blood pressures, suggesting some important differences with the simple administration of oxygen.

4.2. Ujjayi Breath and BRS. Although ujjayi breath showed the greatest increase in oxygen saturation, it did not coincide with the greatest improvement in BRS when done just on the expiration. We believe that this phenomenon is connected to the necessary effort to perform this type of breath. In agreement with this idea, we found that RR interval dropped by effect of ujjayi with respect to slow breathing alone. Accordingly, the improvement in oxygenation induced by ujjayi could have been counteracted by the increased effort and reduced the effect of parasympathetic stimulation induced by slow breathing alone. When done alone on inspiration the increase in BRS was not significantly improved with respect to baseline. In this case, the effects could have mimicked a Mueller manoeuvre. The Mueller manoeuvre is known to strain the heart and would potentially override the parasympathetic effects found in slow breathing [30–32]. Tracing potential neural correlates of ujjayi breath it was suggested that in animals ujjayi-like inspiration is found in threatening conditions of threat and may serve to promote vigilance, thereby mitigating the effects of increased BRS [14].

4.3. Asymmetrical versus Symmetrical Breathing. We did not find any significant difference between asymmetrical and symmetrical breathing during slow breathing. We suggest that most of these results could be due to the prolonged expiratory time (in fact the 3-second inspiratory time of the asymmetrical breathing was very close to the spontaneous breathing). In the yoga tradition several degrees of asymmetries were adopted. While some of these could have specific effects (and could be matter for further investigations), our results suggest that an expiratory time of at least 5 seconds was sufficient to elicit most of the results observed.

4.4. Limitations. In this study, due to the need of avoiding a mouthpiece, we used a simplified, though validated, technique to assess the chemoreflex sensitivity, the $V_{e}/T_{i}$ ratio [26]. While using this approach we did impose one term of the ratio by fixing the $T_{i}$, and we nevertheless left $V_{e}$ free to change. If the manoeuvre was not altering the chemoreflex, then we would have expected a change in $V_{e}$, such that the ratio would stabilise to the same value as the one at baseline. Since this did not happen, it is likely that this ratio was indeed reflecting some change in the chemoreflex. Additionally, these findings are in full agreement with previous studies [11, 33] in which it was shown by us and others that the slow breathing markedly reduced the chemoreflex sensitivity in yoga naive subjects and also in yoga trainees during spontaneous breathing. Being obtained in yoga naive young participants, it is not obvious that our findings could be exactly replicated in older patients or in patients with long-term practice in yoga. It is logical to expect that the habituation in practicing breathing exercise will allow to perform them with less effort and thus with perhaps better results (e.g., lower changes in heart rate), particularly during ujjayi. However, to our best knowledge such information is still lacking, and then it should be tested in future investigations. In this study, we observed the effects of these breathing techniques during their application only. The long-term effects of yoga practice could be of high interest, but the specific contribution of each breathing technique cannot be easily identified, as in general yoga trainees use a variety of many different breathing techniques in addition to postures and mediation. However, the same directional changes have been confirmed both for yoga practice [33–35] and also for the specific effects of slow breathing alone [7].

5. Conclusions

Based on our findings, slow breathing with similar inspiration and expiration times appears the most effective and simple way to heighten the BRS and improve oxygenation in normoxia. Ujjayi breath demonstrates limited added benefit over slow breathing done at 6/min in normoxia; however, the effects could be more pronounced in hypoxia, and this could be matter for future investigations. As we did not find a significant difference in symmetrical versus asymmetrical breathing, it is suggested that practitioners can engage in a ratio that is personally comfortable and achieve the same BRS benefit. These findings might be relevant for selecting the optimal strategy to train patients undergoing yoga-based rehabilitation programs, as previous studies have shown that patients with different pathologic conditions (such as heart failure, hypertension, and COPD) may benefit from practice in these slow breathing [2–4, 7], while no contraindications to date have been reported.

Conflict of Interests

The authors declared that there is no conflict of interests.

Acknowledgment

The authors gratefully acknowledge the help of Engineer Michele Neri (Ambiter, Parma, Italy) for writing part of the software used for this study.

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Research Article

A Yoga and Compassion Meditation Program Reduces Stress in Familial Caregivers of Alzheimer’s Disease Patients

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Received 13 December 2012; Accepted 29 March 2013

Academic Editor: Luciano Bernardi

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Familial caregivers of patients with Alzheimer’s disease exhibit reduced quality of life and increased stress levels. The aim of this study was to investigate the effects of an 8-week yoga and compassion meditation program on the perceived stress, anxiety, depression, and salivary cortisol levels in familial caregivers. A total of 46 volunteers were randomly assigned to participate in a stress-reduction program for a 2-month period (yoga and compassion meditation program—YCMP group) (n = 25) or an untreated group for the same period of time (control group) (n = 21). The levels of stress, anxiety, depression, and morning salivary cortisol of the participants were measured before and after intervention. The groups were initially homogeneous; however, after intervention, the groups diverged significantly. The YCMP group exhibited a reduction of the stress (P < 0.05), anxiety (P < 0.000001), and depression (P < 0.00001) levels, as well as a reduction in the concentration of salivary cortisol (P < 0.05). Our study suggests that an 8-week yoga and compassion meditation program may offer an effective intervention for reducing perceived stress, anxiety, depression, and salivary cortisol in familial caregivers.

1. Introduction

The aging of the worldwide population has contributed to the increasing incidence of dementia-causing chronic degenerative diseases, notably Alzheimer’s disease [1]. Alzheimer’s disease is the most common form of dementia and is characterized as a progressive brain disorder with loss of reasoning, memory, language skills, and the ability to maintain an independent life [2]. The caregivers of Alzheimer’s disease patients are typically family members [3]. The physical and mental burden imposed on caregivers frequently results in poor quality of life [4]. The physical, mental, social, and financial burden to which caregivers are exposed to might result in an increased risk of acute myocardial infarction and death [5–7]. Among the several psychosocial contexts experienced by caregivers, the following are particularly noteworthy: stress, social exclusion, depression, emotional isolation, burnout of personal relationships, loss of life perspectives, sleep disorders, and abuse of psychotropic substances [8–13]. Several studies of Alzheimer’s disease patients and caregivers stress the importance of the medical team orienting the familial caregivers beginning in the earliest stages of disease, and plans for such support interventions have been suggested in the literature [14–16]. Yoga and meditation are among the modalities of intervention that might be applied to this population.

One of the most appropriate definitions of yoga is found in documents dated approximately 2,000 years ago, namely, Patanjali’s Yoga sutras. One of such sutras defines yoga as follows: yoga is the restriction of the fluctuations of mind-stuff [17]. Thus, one of the aims of yoga is the development of mindfulness; several meditation techniques exhibit similar
goals. Although meditation is a component of yoga, there are other approaches to meditation, such as compassion meditation, which originated in Buddhism, that are not associated with bodily practices, as in yoga. For this reason, both terms, yoga and meditation, will be used throughout the present paper.

Practices related with yoga and meditation have been investigated as potential techniques for reducing stress [18–21], anxiety [21–23], and depression [21, 23]; for improving physical and mental wellbeing and several domains of cognition [23, 24]; and for enhancing quality of life [25, 26]. During these practices, the participant develops the ability of focused attention to the present moment, instead of being arrested by thoughts and ruminations [18]. This mental stability seems to be related to sympathetic reduction and conversely improvement in the parasympathetic activity contributing to stress and anxiety reductions [18–20, 27].

Few studies investigated the stress levels of the caregivers of patients with chronic diseases before and after such interventions as yoga and meditation. A pilot study applied a program known as Inner Resources as therapy to 12 women responsible for the care of relatives with dementia. The protocol developed by that program included meditation, yoga body positions and respiration techniques, and visualizations and repetitions of specific sounds, which are known as mantras. The application of specific questionnaires allowed the researchers to detect improvement in the caregivers’ state of depression and anxiety [22]. A more recent study found similar results upon assessing the effects of meditation on perceived stress and related indices of psychological status in Alzheimer’s disease patients and their caregivers [27]. However, these results must be interpreted cautiously, as neither study included a control group, and the sample sizes were small in both cases.

In addition to the emotional stress that caregivers suffer upon seeing their relative deteriorate physically and mentally, caregivers of patients with Alzheimer’s disease must perform physical labor. Therefore, the aim of the present study was to investigate whether the practice of a yoga and compassion meditation program might alter the stress, anxiety, and depression levels of familial caregivers of patients with Alzheimer’s disease, as measured on standardized questionnaires. The present study also sought to assess whether the intervention modified the caregivers’ morning cortisol level.

2. Methods

2.1. Study Participants. The present study was approved by the Research Ethics Committee of UNIFESP, Protocol no. 1528/07. The study volunteers were recruited by means of announcements on radios and newspapers placed the Press Consultancy of UNIFESP and were also referred by the Brazil Alzheimer’s Association (Associação Brasileira de Alzheimer—ABRAZ). The inclusion criteria were as follows: older than 18 years of age, minimum educational level corresponding to complete elementary education, and exhibiting at least the resistance stage of stress on Lipp’s Stress Symptoms Inventory for Adults (LSSI) [28]. The exclusion criteria were as the following: diagnosis of Cushing’s syndrome; ongoing treatment with corticoids per any route, including the topical and nasal ones in the previous 30 days; diagnosis of asthma or chronic obstructive pulmonary diseases (COPD); use of alcohol (more than five drinks per week) or drugs of abuse; and regular practice of yoga, meditation, or similar techniques. The use of tranquilizers was not an exclusion criterion, provided that the volunteers started it before the study and did not discontinue it during the study period. A total of 53 familial caregivers of Alzheimer’s disease patients were selected. Forty-six of the subjects completed all of the stages of the study after random allocation into 2 groups: 25 volunteers (22 females and 3 males) participated in the yoga and compassion meditation program (YCMP group), and 21 (19 females and two males) volunteers made up the control group (CG), which was a nontreated group. For ethical reasons, after the end of the study, the volunteers in the CG also participated in the suggested intervention. The participants visited the Psychobiology Department of UNIFESP, where they were subjected to clinical examination to assess their overall health, filled in identification questionnaires, and signed a free and informed consent form. Next, the volunteers filled in the psychological scales and inventories and were instructed to the procedures to collect salivary samples to measure cortisol levels. These same assessments were performed two months later in both groups.

2.2. Outcome Measures. The following instruments were used to measure the psychological aspects.

(a) Lipp’s Stress Symptoms Inventory for Adults (LSSI), which has been frequently used in Brazil in recent years and categorizes stress according to a four-phase model, namely, alertness, resistance, quasiexhaustion, and exhaustion according to the amount of physical and psychological stress symptoms [28].

(b) Beck Depression Inventory (BDI) and Beck Anxiety Inventory (BAI), both comprising 21 questions describing depression and anxiety symptoms to which subjects respond on a four-point scale [29–32].

(c) In addition, the salivary cortisol level was used as a measure of physiological stress. For that purpose, 8 samples were collected from each participant. Four samples were collected before the intervention: two samples were collected on 2 consecutive days, both immediately and 30 minutes after waking up, under fasting conditions. Additional 4 samples were collected following the same procedures after intervention. Morning was selected as the time for sample collection because it corresponds to the maximum peak of cortisol throughout the day [33–36]. As the morning cortisol level is sensitive to light—the greater the luminosity, the higher the cortisol concentration—[35], the volunteers were oriented to perform the first sample collection immediately upon waking up and in the dark, and the second sample was collected 30 minutes later under exposure to natural light. We analyzed the results based on
the average results of the first day samples, the second day samples, and the overall average of both days. The samples were processed at the Laboratory of Steroids of the Department of Endocrinology of UNIFESP. The samples were centrifuged at 3,000 rpm for 5 minutes, and the supernatant was stored at −20°C until testing, which was performed by means of radioimmunoassay (RIA). Each sample was tested in duplicate using 100 μL of supernatant without any previous extraction [37]. An antibody (cortisol-3-(O-carboxymethyl)-oxime-bovine) highly specific for cortisol (100%) but without significant cross-reactivity with other steroids (<1%) was used.

2.3. Intervention. The stress reduction program lasted 2 months, with sessions lasting 1 hour and 15 minutes, 3 times per week. The participants had to attend 1 live session per week, totaling eight live sessions, whereas the other 2 weekly sessions (16 sessions) were performed at home with the aid of a DVD. The program included the following traditional Hatha Yoga exercises.

(a) Yoga body poses (asanas) (25 min): Sukhasana—practitioner sits with the legs crossed and the back straight. Vajrasana—practitioner sits on the heels, keeping the legs and thighs together, and the back straight. Yoga-Mudra—practitioner sits on the heels, keeping the legs and thighs together, and the back bent forward. Paschimottanasana—practitioner sits with the knees stretched, feet together, and back bent forward. Ardha-Matsyendrasana—practitioner sits intertwining the legs, the back straight, and twists the back to look behind; this movement is performed in both directions. Shavasana—practitioner lies on the floor, on the back, with the arms along the body, and the knees extended. Naukasana—practitioner lies on the floor, on the back, then raises the legs and trunk from the floor, and keeps this position as long as it is comfortable. Bhujangasana—practitioner lies on the floor, on the abdomen, with the palms of the hands on the floor, at the pectoral level. Upon the instructor’s command, the practitioner raises the trunk gently from the floor while stretching the back. Ardha-Shalabhasana—practitioner lies on the floor, on the abdomen, with the arms along the body, legs together, and knees stretched. Upon the instructor’s command, the practitioner raises one thigh from the floor; this movement is performed on both sides. Standing Chakrasana—practitioner stands with the feet together, raises the right arm, and bends the trunk toward the left side; this movement is performed on both sides. Vrikasana—practitioner stands with the feet together, removes the right foot from the floor, and places it on the internal side of the left thigh. Next, he/she joins the palms of the hands in front of the chest, raises the arms above the head, and remains in this position, keeping the balance, as long as it is comfortable. This movement is performed on both sides. Sarvangasana—at the beginning of this movement, the practitioner lies on the floor, on the back. The aim of this exercise is to raise the legs, thighs, and hips from the floor, that is, to attain an upside-down position, while supporting the body on the upper part of the back, upper arms up to the elbows, and the back of the head. The asanas’ average duration of each movement was approximately one and a half minutes [38, 39].

(b) Exercises involving awareness and voluntary regulation of breath (pranayamas) (25 min): Adhama Pranayama—free, predominantly abdominal respiration. Bhastrika—forceful expirations through the nose followed by passive inspirations. Ujjayi—slow and complete inspiration, retention of the air in the lungs, and slow expiration through partially closed glottis. Surya Bhedana—inspiration through the right nostril followed by expiration through the left nostril. Chandra bhedana—inspiration through the left nostril followed by expiration through the right nostril. Nadi Shodhana—inspiration through the left nostril, retention of air in the lungs, expiration through the right nostril, inspiration through the right nostril, retention of air in the lungs, and expiration through the left nostril. Kapalbhati—forceful, short, and fast expiration through the nostrils followed by passive inspiration [38, 39]. The pranayamas’ average duration of each one was approximately three minutes [40, 41] (12.5 min).

(c.1) Meditational practices: mindfulness meditation adapted for Western psychology, originating in Buddhist meditation, involves paying sustained attention to sensations, perceptions, and thoughts with suspension of judgment [18].

(c.2) Compassion meditation: compassion meditation (karuna) emphasizes the voluntary production of compassionate feelings for all living beings based on the assumption that all beings aspire to happiness and seek to release themselves from suffering and its causes [42, 43] (12.5 min).

2.4. Statistical Analysis. To establish whether the groups were similar before the intervention, the chi-square ($\chi^2$) test was applied to the nominal and ordinal qualitative variables, and Student's $t$-test was applied to the quantitative variables. To analyze the psychological (BDI and BAI) and physiological (cortisol level) measurements, 2-way ANOVA was applied (YCMP and CG groups) (before and after intervention) followed by Tukey’s test when necessary. The differences between the groups and the time-points were investigated according to their statistical significance and as was the interaction between these factors. With respect to LSSI, the chi-square test ($\chi^2$) was used to compare the groups before and after intervention. To assess the effect of intervention, that is, to compare the results after intervention to the ones before intervention, McNemar’s test was applied to each category of phases of stress. All of the statistical analyses
were performed using software Statistica version 10.1, and the significance level was established as $P \leq 0.05$.

3. Results

Before the intervention, both groups were statistically homogeneous with respect to the following variables: male gender (YCMP, $n = 3$, 12%) (CG, $n = 2$, 10%) and female gender (YCMP, $n = 22$, 88%) (CG, $n = 19$, 90%); educational level, complete elementary education (YCMP, $n = 1$, 4%) (CG, $n = 0$, 0%), complete secondary education (YCMP, $n = 11$, 44%) (CG, $n = 5$, 24%), and complete higher education (YCMP, $n = 13$, 52%) (CG, $n = 16$, 76%); family income (minimum wage, MW = BRL 622.00) up to five times the MW (BRL 3,110.00) (YCMP, $n = 6$) (CG, $n = 7$), more than five and up to 10 times the MW (BRL 3,110.00 to BRL 6,220.00) (YCMP, $n = 11$) (CG, $n = 6$), over 10 times the MW (above BRL 6,220.00) (YCMP, $n = 8$), (CG, $n = 8$); age (YCMP, 55.5 $\pm$ 8.1 years), (CG, 53.4 $\pm$ 8.2 years); and length of caregiving (YCMP, 4.2 $\pm$ 3.3 years) (CG, 5.7 $\pm$ 3.7 years).

The participants in the YCMP group reported 100% commitment to the suggested program. This level of adherence was most likely facilitated by the relative flexibility of the program, as the live sessions could be attended at five different times and at three different locations in the city of São Paulo. Further, the use of the DVD for practice at home facilitated the optimal rate of adherence to the protocol.

Table 1 shows the frequency of distribution of the phases of stress manifestation in both groups. Before the intervention, the groups were statistically similar in this regard: $\chi^2$ ($P > 0.05$). No participant in any group was in either the absent or alert stages, 86% in the CG and 80% in the YCMP group were in the phase of resistance, 14% in the CG, and 12% in the YCMP group were in the phase of quasi-exhaustion, and only 2 individuals in the YCMP group were in the phase of exhaustion. However, after intervention, the groups exhibited statistically significant differences: $\chi^2$ ($P < 0.05$). No participant in the CG group was in either the absent or alert phase, whereas 68% of the participants in the YCMP shifted to the phase characterized by absence of stress manifestations. Table 1 further demonstrates that statistically significant diagnostic changes occurred in the YCMP group. Before the intervention, 20 volunteers were in the phase of resistance, and none of the volunteers was in the phase of absence. After the intervention, only 8 volunteers were in the phase of resistance, and the other 17 volunteers were in the phase of absence: McNemar’s test ($P < 0.05$). Conversely, the CG did not exhibit any statistically significant change between the beginning and the end of intervention.

Table 2 demonstrates that the average depression (BDI) and anxiety (BAI) scores exhibited statistically significant interactions with the time point and group factors. These interactions suggest that the groups’ profiles differed over time. Both variables exhibited a significant reduction in the YCMP group in addition to a difference between the groups after the intervention. The YCMP group exhibited a 51.2% reduction in the BDI score after the intervention, whereas the CG exhibited an increase of 9.5% at the same time point.

### Table 1: Frequency of the distribution of the phases of stress manifestation among the sampled individuals according to group before and after intervention.

| Phases of stress manifestation | Before intervention | After intervention |
|--------------------------------|---------------------|--------------------|
|                                 | Control group       | YCMP group         |
| Absent                         | 0 (0)               | 17 (68)*           |
| Alert                          | 0 (0)               | 0 (0)              |
| Resistance                     | 18 (86)             | 16 (76)            |
| Quasiexhaustion                | 3 (14)              | 4 (19)             |
| Exhaustion                     | 0 (0)               | 1 (5)              |

Data described as frequency (percentage); *$P < 0.05$; differs from control group. chi-square test; McNemar’s test.

The YCMP group exhibited a 49.4% reduction in the BAI score, whereas the CG exhibited an increase of 10% at the same time point.

Table 3 presents the salivary cortisol concentration values corresponding to the average of the two measurements on the first sampling day (day one), the average of the two measurements on the second sampling day (day two), and the average of the four measurements performed over both days (day one and day two). The YCMP group exhibited a statistically significant reduction in the salivary cortisol level on day two (not in day one), as well as a reduction in the average of day one + day two before and after intervention. The differences, according to the table, are not significant in group factor, but they are significant in time and interaction factors. The control group did not exhibit any significant change. Some samples had an insufficient volume of saliva to perform cortisol analysis and were lost as a result. On the first day of the preintervention phase for the YCMG group, we lost 20% of the saliva samples for cortisol analysis, and on the second day we lost 18%, giving an overall loss of 19%. In the same group, in the post-intervention phase, we lost 30%, 26% and 28% of saliva samples, respectively, for the same reason. There were also losses in the CG: on the first day of the preintervention phase there was a loss of 11.90% of the samples, 14.29% on the second day, giving an overall loss of 13.10%. In the post-intervention phase, we lost 14.29%, 28.57% and 21.43%, respectively.

4. Discussion

The present study sought to establish whether an intervention using yoga and compassion meditation exercises could change stress, anxiety, and depression scores and reduce the salivary cortisol levels of familial caregivers of Alzheimer’s
The intervention group exhibited a statistically significant reduction in the stress and anxiety scores, thus indicating that this type of intervention might be useful to reduce stress in the healthcare professionals directly involved with patient care tasks [47]. The literature includes further evidence indicating that the application of these practices might be useful when applied to caregivers [22, 27], and our study corroborates such findings.

Our data demonstrate statistically significant reduction in the depressive symptoms among the participants in the YCMP group. An emergent body of evidence points to the possible therapeutic effects of the practice of aerobic or anaerobic exercises on depression [48–50]. Such exercises, meanwhile, might be either mindful or nonmindful physical exercises. A systematic review analyzed possible therapeutic differences between these two types of exercise. The analyzed results were provided by 12 studies that complied with the methodological criteria applied by the authors for inclusion in that review. According to the authors, both mindful and nonmindful exercises proved to be effective in reducing depression symptoms [50]. It is worth noting that among other activities, the volunteers in our study were subjected to the practice of hatha yoga, which includes physical exercise, most of them anaerobic, to achieve that same goal. Nevertheless, our results

disease patients. Among the most relevant findings were the changes in the stress manifestation phases of the participants in the YCMP group from the categories of resistance (N = 20), quasiexhaustion (N = 3), and exhaustion (N = 2) to absence (N = 17) and resistance (N = 8), thereby demonstrating the effectiveness of the intervention. The changes exhibited by the YCMP group in the stress indices measured by LSSI suggest that our program was able to reverse the stress-related symptoms exhibited by that group (Table 1).

Elevations in the hypothalamic pituitary adrenal (HPA) axis are common occurrences under conditions of chronic psychological stress and result in increased cortisol levels. Such occurrences are associated with hippocampal volume loss and memory impairment and might increase the risk of dementia in older adults [44–46], eventually creating a vicious circle, whereby familial caregivers of patients with Alzheimer’s disease become future patients. Kang et al. [47] applied a program similar to the one used in this study and observed a statistically significant reduction in the stress and anxiety levels of 16 nursing students paired with 16 volunteers, who constituted the control group. In the study, the intervention group performed the suggested program, comprising one weekly session, with each session lasting from one hour and a half to two hours over two months.

### Table 2: Scores of depression and anxiety measured by BDI and BAI of familial caregivers of Alzheimer’s disease patients before and after intervention.

|          | Before       | After       | F_{time-point(1.44)} | F_{group(1.44)} | F_{inter(1.44)} |
|----------|--------------|-------------|----------------------|-----------------|-----------------|
| **BDI**  |              |             |                      |                 |                 |
| Control  | 14.7 (±9.5)  | 16.1 (±10.2)| 16.5                | 2.0             | 34.7            |
| YCMP     | 16.0 (±7.8)  | 8.2 (±4.6)* | P < 0.001           | P = 0.16        | P < 0.000001    |
| **BAI**  |              |             |                      |                 |                 |
| Control  | 19.9 (±10.2) | 21.9 (±10.6)| 12.9                | 9.6             | 32.3            |
| YCMP     | 17.6 (±9.4)  | 8.7 (±5.5)* | P < 0.001           | P < 0.001       | P < 0.00001     |

Data are described as the mean (±standard deviation); *P < 0.001 differs from the time point before the intervention in the corresponding group—Tukey’s test; &P < 0.001 differs from the control group in the corresponding time point—Tukey’s test.

YCMP: yoga and compassion meditation program.

### Table 3: Salivary cortisol concentration (ng/dL) of familial caregivers of Alzheimer’s disease patients before and after intervention.

|          | Before       | After       | F_{time-point(1.35)} | F_{group(1.35)} | F_{inter(1.35)} |
|----------|--------------|-------------|----------------------|-----------------|-----------------|
| **Cortisol day 1** |              |             |                      |                 |                 |
| Control  | 539.4 (±152.6)| 531.1 (±53.7)| 3.64                 | 0.10            | 3.31            |
| YCMP     | 743.9 (±140.7)| 404.4 (±49.5)| P = 0.06            | P = 0.76        | P = 0.08        |
| **Cortisol day 2** |              |             |                      |                 |                 |
| Control  | 674.7 (±181.7)| 673.2 (±86.3)| 7.42                 | 0.00004        | 7.33            |
| YCMP     | 937.6 (±171.3)| 408.1 (±81.3)*| P < 0.05            | P = 0.99        | P < 0.05        |
| **Cortisol days 1 and 2** |              |             |                      |                 |                 |
| Control  | 641.5 (±137.6)| 568.0 (±58.03)| 8.38                 | 0.02            | 3.97            |
| YCMP     | 823.0 (±131.2)| 424.6 (±55.3)*| P < 0.001           | P = 0.88        | P < 0.05        |

Data are described as the mean (±standard deviation); *P < 0.05 differs from the time point before the intervention in the corresponding group—Tukey’s test.

YCMP: yoga and compassion meditation program.
cannot be discussed on the grounds of the therapeutic effects of the practice of physical exercise alone because our purpose was to subject the volunteers to a program that included mindful exercises and compassion meditation. Therefore, our results must be attributed to the program as such and not merely to one of its parts. In addition, Kozasa et al. investigated the efficiency of a program that included mantra meditation and pranayamas, known as Siddha Samadhi Yoga, in reducing scores of anxiety and depression in participants with anxiety complaints. This program includes meditation exercises associated with exercises of respiration (pranayamas). A total of 22 volunteers participated in that study, with 14 volunteers being allocated to the intervention group and eight to the control group. The volunteers in the intervention group were oriented to practice the exercise protocol every day of the week, three times per day, in 15-minute sessions. At the end of the study, as in ours, the intervention group exhibited a significant reduction in the anxiety and depression scores compared to the control group [51].

A relationship between practices involving meditation and the endocrine and immune systems has been analyzed in the scientific literature. Witek-Janusek et al. observed a reduction in cortisol concentrations and an improvement of immune system function among women diagnosed with breast cancer who were subjected to the mindfulness-based stress reduction (MBSR) program compared to a control group also comprising women with breast cancer [52]. In the present study, we chose to measure the salivary cortisol levels as a physiological variable sensitive to the behavioral modifications to which the volunteers were subjected. As presented in Table 3, our results indicate that the changes exhibited by the YCMP group, with respect to the cortisol levels of the samples collected on the second day and the total average of the samples collected on the first and second days, were higher compared to the control group. Our results indicate that the participants in the YCMP group developed psychophysiological adaptations associated with the participation in the indicated program, although we did not find statistically significant differences between the groups in the measurements of salivary cortisol performed after the intervention.

During the study, we hypothesized that the caregivers’ menstrual cycle phase might interfere with the results; however, we were not able to control this variable. However, one study investigated the morning salivary cortisol levels in 99 women and did not find any correlation between the menstrual cycle phase and salivary cortisol levels [53]. It is also worth noting that, according to the literature, the earlier individuals wake, the higher the morning cortisol levels are [54, 55]. As a function of the characteristics of our study sample, all of the participants awoke between 7:00 and 8:00 am. Although this fact most likely reduced the probability of interferences related to different waking times, we were not able to control this variable in a more rigorous manner. One issue deserving discussion is the fact that nicotine is known to be a powerful stimulator of the hypothalamic-pituitary-adrenal axis (HPA) [56]. Consequently, smoking could interfere with the correlation between cortisol levels and stress.

Nevertheless, only two volunteers (both in the YCMP group) in our total sample (46 familial caregivers) were smokers. We believed that this low number noticeably reduced the possibility of interference associated with smoking.

Comparing to previous studies with familial caregivers, [22, 27], the present study is randomized and controlled and has a bigger sample. However, the CG had no treatment, and it could be a limitation of the study. We suggest that similar studies include an active control group which can be a stress discussion group, for example. Another interesting data not collected in this study was the impact of the caregiver’s stress reduction on the Alzheimer’s patients.

Like mentioned in the introduction, the mental stability could be related to sympathetic reduction and improvement in the parasympathetic activity contributing to stress and anxiety reductions. Many other studies about the effects of meditation practice have been indicating a number of physiological changes, such as increased GABA concentration [57], adrenaline and noradrenaline reductions [58], increased serotonin [59] and melatonin concentrations [60], which can be related to improvements on mood, reductions in body temperature [61, 62] and increased galvanic skin resistance [63], may be related to stress management, and also increased gray matter density in brain regions related to emotional regulation [64]. New studies with familial caregivers would evaluate more physiological parameters than presented in this study.

5. Conclusions
The results our study demonstrate are that the practice of yoga and the suggested meditation techniques may represent an effective intervention for caregivers of relatives with Alzheimer’s disease to reduce their stress, anxiety, and depression symptoms and to decrease their cortisol levels.

Acknowledgment
The authors thank Associação Fundo de Incentivo à Pesquisa-AFIP for providing financial support.

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