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Improvement in physiological and psychological parameters after 6 months of yoga practice

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ABSTRACT

Yoga is believed to have beneficial effects on cognition, attenuation of emotional intensity and stress reduction. Previous studies were mainly performed on eastern experienced practitioners or unhealthy subjects undergoing concomitant conventional therapies. Further investigation is needed on the effects of yoga per se, as well as its possible preventive benefits on healthy subjects. We investigated the effects of yoga on memory and psychophysiological parameters related to stress, comparing yoga practice and conventional physical exercises in healthy men (previously yoga-naïve). Memory tests, salivary cortisol levels and stress, anxiety, and depression inventories were assessed before and after 6 months of practice. Yoga practitioners showed improvement of the memory performance, as well as improvements in psychophysiological parameters. The present results suggest that regular yoga practice can improve aspects of cognition and quality of life for healthy individuals. An indirect influence of emotional state on cognitive improvement promoted by yoga practice can be proposed.

1. Introduction

Yoga is an ancient Indian system of philosophy designed to bring balance and health to the physical, mental and emotional dimensions of the individual. The practice consists of a set of physical postures (“*asanas*”), which are maintained for a certain time (Ross & Thomas, 2010). Yoga also involves practice of voluntary breath control (*pranayama*), voluntary concentration of thoughts (meditation) and/or repeated recital of phrases (mantra). *Asanas* are exercises traditionally used in yoga practices characterized by the maintenance of specific postures involving bending, standing, twisting and balancing the body, with the objective of improving flexibility and strength. *Pranayamas* consist of controlled breathing exercises focusing body awareness during their execution. Meditation is a mental process involving voluntary concentration of thoughts, aiming an altered state of awareness, believed to produce changes in perception, attention and cognition (Pilkington, Kikwood, Rampes, & Richardson, 2005; Ross & Thomas, 2010). Since its introduction into the Western culture, yoga has becoming more popular as a complementary way to achieve healthy living (Jayasinghe, 2004).

A growing body of evidence supports the belief that yoga techniques and other types of mind–body therapies may improve physical and mental health (Astin, 1997; Elsenbruch et al., 2005; Grossman, Tiefenthaler-Gilmer, Raysz, & Kesper,

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2007; Nakao et al., 2001; Ross & Thomas, 2010). Moreover, investigations have shown the beneficial effects of yoga on cognition (Birdee et al., 2009). Rangan, Nagendra, and Bhat (2009), for example, verified that the Gurukula Education System School, based on a *yoga way of life*, was more effective in increasing performance on visual and verbal memory in students when compared with students of the Modern Education System. Another study showed that yoga-based relaxation techniques improved memory scores in volunteers immediately after the practice (Subramanya & Telles, 2009).

Among practitioners and instructors, it is believed that yoga practice provide benefits in both cognitive and affective aspects of psychological functions such as memory improvement and the reduction of emotional tension, depression, anxiety and irritability (Andrade & Pedrão, 2005). In general, mind and body control techniques can have potential beneficial effects on cognition because they involve active attention exercises. For example, it has been shown that yoga practice enhances the subject's attention on breathing and specific body muscles, referring to a general improvement in attentional capacity (Oken et al., 2006). On the other hand, cognition improvement could be indirectly achieved by the attenuation of emotional intensity and stress reduction induced by the regular practice of Yoga. Indeed, stress, anxiety, depression and other psychologically debilitating conditions have been associated with cognitive deficits (Birdee et al., 2009; Rajesh, Jayachandran, Mohandas, & Radhakrishnan, 2006; Sharma, Das, Mondal, Goswami, & Gandhi, 2006; Subramanya & Telles, 2009). Additionally, many studies support the idea that yoga benefits physical and mental health via down-regulation of the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic nervous system (SNS) activity (Ross & Thomas, 2010 for review). In this respect, the practice of yoga was shown to improve mood in a way comparable to aerobic exercise (Berger & Owen, 1992).

In general, physical exercises have been considered an acceptable method for improving and maintaining physical and emotional health (Ross & Thomas, 2010). Studies comparing the effects of yoga and conventional physical exercise seem to indicate that, in both healthy and unhealthy subjects, yoga may be as effective as, or even better than, exercise at improving a variety of health-related outcome measures (Ankad, Herur, Patil, Shashikala, & Chinagudi, 2011; Pilkington et al., 2005; Yurkuran, Alp, Yurtkuran, & Dilek, 2007).

Despite the growing number of studies on the subject, the lack of evidence based on rigorous scientific approaches has limited application of yoga as an accepted method for health improvement or even disease treatment. Indeed, although one can find in the scientific literature an increasing number of studies designed to clarify the validity of the practice, important methodological limitations of the studies emphasize the need for further research (Birdee et al., 2009; Chiesa & Serretti, 2009; Tsang, Chan, & Cheung, 2008). Research protocols of these studies were varied in type of yoga practice, subject age and different physical and psychological profiles, usually presenting physical or mental disorders (Ross & Thomas, 2010). Additionally, long term yoga practitioners are included in the studies that lack information about the subjects' evaluations before yoga practice. Other studies fail to control the effects of physical exercise per se, usually using relaxation or even no activity at all as control conditions (Evans et al., 2011; Javnbakht, Hejazi, & Ghasemi, 2009; John, Sharma, Sharma, & Kankane, 2007; Subramanya & Telles, 2009; Yoshihara, Hiramoto, Sudo, & Kubo, 2011). Most studies have focused on yoga practice as an adjuvant therapy, i.e., the conclusions are based on the effects of yoga practice associated with medication, special diets, conventional physical therapies, and others (Birdee et al., 2009; Rani et al., 2011; Telles, Naveen, Balkrishna, & Kumar, 2010; Yogitha, Nagarathna, John, & Nagendra, 2010). Finally, most of the yoga studies are performed in eastern populations, where individuals are culturally predisposed to this kind of practice. In this respect, one might ask if the adaptation of yoga practice to western way of life is equally effective.

Clearly, further investigation is needed on the effects of yoga practice per se, as well as the possible preventive benefits of this practice on healthy subjects. Therefore, the aim of this study is to examine the effectiveness of yoga practice on behavioral and physiological measures related to emotional and cognitive aspects of yoga-naive subjects, who undergo similar daily activities in a common environment, and hence submitted to a common set of daily stressors. Specifically, this study investigated the effects of yoga practice on memory, psychological measures and salivary cortisol levels of healthy adult, Brazilian military men.

2. Methods

2.1. Participants

Thirty-six men (aged 20–40 years old) from the Brazilian army participated in this study. The participants' health conditions are periodically checked as part of the military routine and they were all healthy during the period of the study. All subjects were submitted to conventional physical exercises, and kept to the same daily work conditions (military quarter's routine). Exclusion criteria were the presence of psychiatric illness, history of drug abuse, current treatment with drugs acting on the central nervous system, use of steroid hormones or analogs, and previous experience with yoga or similar practices. All subjects signed a consent form and the research protocol was approved by the local Institutional Ethics Committee. Subjects were assigned to either yoga practice or conventional physical exercise (control) groups balanced for age and rank in military hierarchy. The yoga group ($n = 17$) attended two yoga classes a week plus two physical exercise classes, while the control group ($n = 19$) attended only physical exercises (four classes a week) for a period of 6 months. All classes lasted 60 min. Outcome assessments were performed at baseline and at the end of the 6-month period. These evaluations consisted of standard inventories, salivary cortisol levels and memory tests (word list recognition). Both collection and data analysis

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were conducted blind to the experimenter. Subjects were specifically instructed to avoid telling the assessor what intervention group they were in.

2.2. Inventories

At admission, all individuals were required to answer a personal information questionnaire. In addition, the BDI (Beck Depression Inventory), the BAI (Beck Anxiety Inventory) and the LSSI (Lipp Stress Symptom Inventory) were applied at baseline and after the 6 months of practice.

The BDI is one of the most widely used and reliable instrument for detecting and assessing intensity of depression in normal populations (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Javnbakht et al., 2009). The 21-item BDI self-report questionnaire assesses any depressive and affective symptoms in the previous week and rates their intensity on a scale from 0 to 3 (total score range 0–63). The final score can indicate four possible depression mood levels: 0–11 (minimally depressed mood), 12–19 (lightly depressed mood), 20–35 (moderately depressed mood), and 30–63 (severely depressed). Most items describe clinical symptoms of depression, specifically the presence and intensity of emotional, cognitive, and somatic aspects (Beck et al., 1961; Gorenstein & Andrade, 1996; Javnbakht et al., 2009).

The BAI, one of the most commonly used measures to assess the construct of anxiety (Gorenstein & Andrade, 1996), includes 21 items that reflect affective and somatic symptoms of anxiety, and are rated on a 4-point scale for how much the individual is bothered by these symptoms during the past week: 0 (not at all) to 3 (severely), with a possible range of total scores from 0 to 63. Higher scores represent a higher intensity of anxiety (Cunha, 2001; Gorenstein & Andrade, 1996).

The LSSI, a psychological evaluation tool validated for use in Brazil, was used to identify the symptoms of stress presented by the subjects by registering the prevalence of physical or psychological symptoms as well as the stress stage (alert stage, resistance, almost-exhaustion, or exhaustion) (Costa, Accioly, Oliveira, & Maia, 2007; Lipp, 2000).

2.3. Memory tests

Memory tests comprised short- and long-term memory of word recognition, in both easy and difficult contexts. The protocol consisted of two lists of 15 common concrete nouns (Portuguese language version). Each word was displayed individually on a computer screen and subsequently a word recognition test was carried out, with the target words mixed with distracting words (distracters). For evaluation of short-term memory, word list presentation and word recognition test were repeated for three trials (T1, T2, and T3). For the "easy" context coding, a new set of distracters was used in each repetition of the word list recognition test, while the same set of distracters was used in all trials for the "difficult" context coding. In order to increase interference in recollection of short-term memory, the Forward Span Digit and the Backward Span Digit tests were applied between T1 and T2 and between T2 and T3, respectively (data not shown). This interference in recollection was added to increase difficulty, which would raise the possibility of finding differences in the performance of the groups. During the three sequential trials, in addition to the evaluation of short-term memory, subjects are expected to learn the lists for future long-term retrieval. In this respect, a preliminary study has shown that three trials is adequate for long-term episodic memory codification in this kind of test (Albuquerque, Barbosa, Leite, & Fuso, 2008). Hence, 1 week later, a word recognition test of each list was conducted to evaluate long-term memory. This whole procedure was performed twice: before the beginning of the practicing period and after 6 months of practice. Target word recall was analyzed by the discrimination accuracy index Pr from the two-high threshold theory (Albuquerque et al., 2008; Corwin, 1994), which reflects the ability to discriminate target words from distracters. Data were computed separately for easy and difficult contexts.

2.4. Salivary cortisol determination

The collection of samples was carried out in the morning (7:00 a.m.) and participants were instructed not to drink or eat anything, nor brush their teeth for at least 2 h prior to the testing. All subjects rinsed their mouth with water prior to saliva collections to minimize contamination of the samples. Saliva was collected in Salivette® (Sarstedt, German) containers and subsequently stored at −80 °C until analysis. Prior to analysis, samples were centrifuged at 10,000*g* for 20 min and analyzed for cortisol concentration using a commercially available KIT DSL-10-671000 ACTIVE® cortisol enzyme immunoassay (EIA).

2.5. Statistical analysis

The Statistical Package for Social Sciences (Version 16.0) was used to conduct all statistical analyses. Kolmogorov–Smirnov test of normality was applied to data from inventories, memory tests and cortisol levels. For the inventories and salivary cortisol levels, comparisons of the parameters between experimental groups were performed by Mann–Whitney *U*-test, and Wilcoxon test was used to compare basal and after practice outcomes within the groups. Regarding memory tests, the mean value between the three trials was used for evaluating short and long-term recollection, since no effect of trial was found. Independent (between the groups) or paired-samples (between baseline and after practice values) *t* tests were used to compare short-term and long-term performances. Easy context and difficult context conditions were evaluated separately. A significance level of .05 was considered to reflect significant differences for all comparisons made.

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3. Results

3.1. Inventories

Data obtained before yoga intervention through the BDI showed that most of the subjects from both groups presented minimum level of depressive symptoms, and about 30% of the individuals in each group presented slight levels of depression. After yoga, intervention, all yoga-practitioners showed minimum level in the depressive symptoms, whereas the percent of control subjects with slight depression levels had not changed in relation to the baseline (Table 1). The analysis of the scores of the BDI (Fig. 1A) did not reveal differences between yoga and control groups at baseline ($U = 155.5$, $p = .85$), but yoga group presented significantly lower scores after 6 months of practice ($U = 60.0$, $p = .001$). Moreover, comparison between baseline and after practice scores showed a significant reduction for yoga group ($z = -3.21$, $p = .001$) but not for control group ($z = -0.39$, $p = .69$).

As shown in Table 1, the percentage of yoga-practitioners presenting minimum anxiety levels as evaluated by the BAI increased, while the percentage of practitioners presenting slight or moderate anxiety levels decreased after 6 months of practice. The analysis of the scores of the BAI (Fig. 1B) showed that before intervention, anxiety levels were not different between the groups ($U = 134.5$, $p = .39$), while yoga group showed decreased scores when compared to control group after the period of practice ($U = 39.0$, $p < .001$). Furthermore, comparisons between baseline and after intervention scores showed significant decrements for yoga group ($z = -3.41$, $p = .001$), but not for control group ($z = -0.86$, $p = .39$).

The results from the LSSI showed that most of the subjects were in the resistance stage of stress symptoms in both control (63.2%) and yoga (94.1%) groups before intervention. However, after 6 months of practice, no stress symptoms were found in yoga group, whereas 79.0% of control subjects were in the resistance or in the almost exhaustion stages (Table 1). The analysis of the scores of the LSSI (Fig. 1C) showed that before intervention, stress levels were not different between groups ($U = 127.0$, $p = .27$), while yoga group showed decreased scores when compared to control group after the period of practice ($U = 10.5$, $p < .001$). Additionally, comparisons between baseline and after intervention scores showed a significant decrement for yoga group ($z = -3.65$, $p < .001$) and a significant increase for control group ($z = -2.55$, $p = .01$).

3.2. Memory tests

The mean of the three sequential recollection trials in the first day of test was used for evaluation of short-term memory. No significant differences were found at baseline measures in any of the codification contexts. After the 6-month period of practice, yoga group performed significantly better in the word recognition test in the easy context when compared to controls [$t(34) = 2.11$, $p \leqslant .05$]. When the same analyses were applied to the difficult context, once again, the performance of yoga practitioners showed improvement when compared to control subjects [$t(34) = 3.53$, $p = .001$]. No differences were found in the comparisons between baseline and after practice performances. Data from the short-term memory tests are displayed in Table 2.

Long-term memory was evaluated in a recollection trial performed 7 days after the first test day. The analysis of the baseline data did not show differences between groups [easy context: $t(34) = 0.07$, $p = .94$; difficult context: $t(34) = 0.45$, $p = .65$]. After 6 months of practice, the yoga group performed significantly better in the easy context when compared to control group [$t(34) = 4.75$, $p \leqslant .001$]. In the difficult context, the difference between controls and yoga practitioners was marginally significant [$t(34) = 1.95$, $p = .059$]. Moreover, paired-samples t test revealed significant improvement only within yoga practitioners when recollection after practice was compared to baseline performance [$t(16) = 2.28$, $p = .03$]. Data from the long-term memory tests are displayed in Table 3.

Table 1
Percentage of control subjects (CONTROL) and yoga practitioners (YOGA) in each category of the depression (BDI), anxiety (BAI) and stress (LSSI) inventories at baseline and after 6 months of practice.

Inventory	Category	Baseline				After 6-months			
		CONTROL		YOGA		CONTROL		YOGA	
		N	%	*N*	%	*N*	%	*N*	%
BDI	Minimum	12	63.2	11	64.7	12	63.2	17	100
	Slight	7	36.8	5	29.4	7	36.8	0	0
	Moderate	0	0	1	5.9	0	0	0	0
	Serious	0	0	0	0	0	0	0	0
BAI	Minimum	9	47.4	10	58.8	7	36.8	15	88.2
	Slight	6	31.6	4	23.5	10	52.6	2	11.8
	Moderate	4	21.0	3	17.6	2	10.6	0	0
	Serious	0	0	0	0	0	0	0	0
LSSI	No symptoms	5	26.3	1	5.9	4	21.0	17	100
	Alert	0	0	0	0	0	0	0	0
	Resistance	12	63.2	16	94.1	13	68.5	0	0
	Almost exhaustion	2	10.5	0	0	2	10.5	0	0
	Exhaustion	0	0	0	0	0	0	0	0

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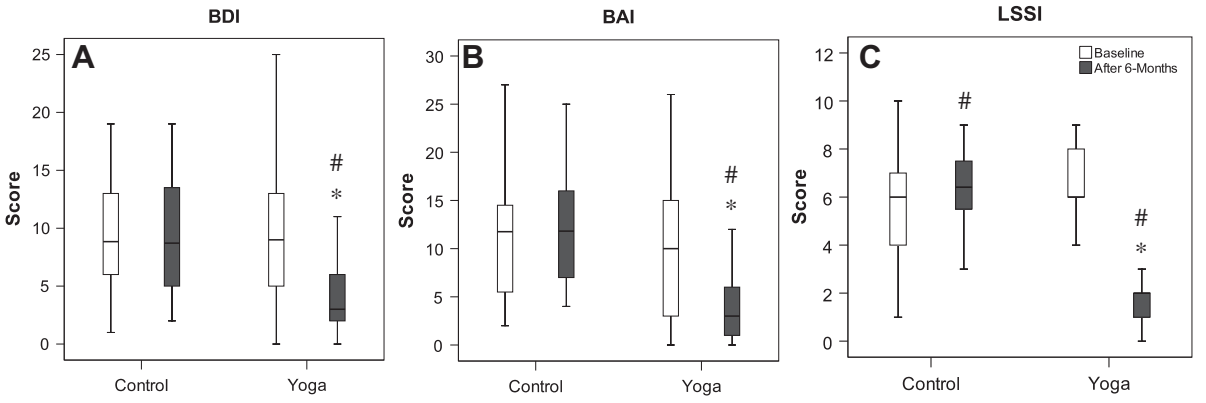

Fig. 1. Score of the inventories applied at baseline and after 6 months of yoga practice for control and yoga groups. (A) Beck Depression Inventory (BDI); (B) Beck Anxiety Inventory (BAI), and (C) Lipp Stress Symptom Inventory (LSSI). $^{*}p < .001$ compared to control group (Mann–Whitney *U*-test) and $^{\#}p < .001$ compared to baseline (Wilcoxon test).

Table 2
Short-term memory of control and yoga groups evaluated by word recognition task in easy (A) and difficult (B) contexts at baseline and after 6 months of practice.

	Easy context		Difficult context	
	Baseline	After 6-months	Baseline	After 6-months
CONTROL	0.78	0.75*	0.75	0.71**
YOGA	0.84	0.80*	0.79	0.82**

* $p < .05$ Compared to control group (independent samples *t* test).
** $p = .001$ Compared to control group (independent samples *t* test).

3.3. Salivary cortisol levels

The analysis of cortisol levels (Fig. 2) before intervention showed increased values in the yoga group compared to control group ($U = 65.5$, $p = .002$). After 6 months, the analysis showed increased salivary cortisol levels ($z = -2.41$, $p = .01$) within control subjects, as opposed to a decrease in the salivary cortisol of yoga-practitioners ($z = -3.62$, $p < .001$), both compared to respective baseline values. Additionally, cortisol levels of yoga group were significantly lower when compared to control group after the period of practice ($U = 43.0$, $p < .001$).

4. Discussion

In summary, the results of our study indicated that a 6-month period of regular yoga practice by healthy male volunteers reduced parameters related to stress, depression and anxiety, as well as improved the performance in a recognition memory task. Importantly, the effects of the practice do not seem to be merely related to a physical practice, since all volunteers underwent regular sessions of conventional physical exercise. Further, the practitioners were previously yoga-naïve, not culturally predisposed to practice it, and did not search for this kind of practice in order to obtain a therapeutic effect. These features, to our view, minimize (although do not abolish) the possibility that our results are due to a placebo effect.

According to the scores obtained with the application of the inventories, the health status of the volunteers comprised minimal to moderate levels of stress, anxiety, and depression at baseline. Regardless, these scores were reduced in the yoga

Table 3
Long-term memory of control and yoga groups evaluated by word recognition task in easy (A) and difficult (B) contexts at baseline and after 6 months of practice.

	Easy context		Difficult context	
	Baseline	After 6-months	Baseline	After 6-months
CONTROL	0.46	0.31*	0.34	0.39
YOGA	0.55	0.61*	0.30	0.53°,#

* $p < .001$ Compared to control group (independent samples *t* test).
° $p = .059$ Compared to control group (independent samples *t* test).
# $p < .05$ Compared to control group (paired samples *t* test).

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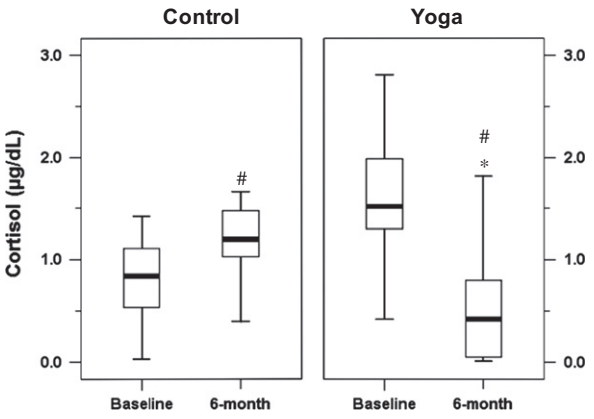

Fig. 2. Salivary cortisol levels of control and yoga groups at baseline and after 6 months of practice. $^{*}p < .01$ compared to control group (Mann–Whitney *U*-test) and $^{\#}p < .001$ compared to baseline (Wilcoxon test).

group after 6 months of regular practice (Table 1). These findings corroborate previous investigations that indicated yoga intervention is effective in reducing anxiety (Javnbakht et al., 2009; Michalsen et al., 2005), depression (Sharma et al., 2006), and stress (Carmody & Baer, 2008). Moreover, another study showed that yoga can be more effective than a relaxation technique in reducing stress, anxiety, depression and improving general health status (Smith, Hancock, Black-Mortimer, & Echert, 2007). Further, anxiety improvement has been considered to be a good indicator of effectiveness of mind–body interventions (Nakao et al., 2001).

The data from salivary cortisol analysis indicated that, under our experimental conditions, yoga practice was effective in reducing this physiological parameter indicative of stress levels (Fig. 2), corroborating the results obtained in the inventories (Table 1 and Fig. 1). It seems relevant to point out that the magnitude of the decrease in the cortisol levels of yoga group after 6 months of practice was higher than those observed in other experimental studies (Biondi & Picardi, 1999; Kunz-Ebrecht, Mohamed-Ali, Feldman, Kirschbaum, & Steptoe, 2003). In this respect, one might speculate that the subjects of this study are submitted to a certain level of stress inherent to military routine which could explain the large responses observed. Alternatively, all participants of the study are also used to regular practice of conventional exercises, a factor that might also increase cortisol levels (Mastorakos, Pavlatou, Diamanti-Kandarakis, & Chrousos, 2005; Viru & Viru, 2004).

The results of the recognition memory tasks showed that control and yoga groups did not differ at baseline. Nevertheless, the performance of yoga group was significantly better after 6 months of practice for both short-term (Table 2) and long-term (Table 3) retrieval tests. This result is in line with few previous studies showing the improvement of cognitive parameters after yoga practice. However, these previous studies were mostly performed with subjects presenting previous deficits (Michalsen et al., 2005) or without appropriate control groups (Berger & Owen, 1992; Smith et al., 2007; Subramanya & Telles, 2009; West, Otte, Geher, Johnson, & Mohr, 2004). Additionally, the present study contributes to the field showing these positive effects upon healthy adults, controlled for the variable of physical exercise, which has also shown to improve cognitive function in previous studies (Colcombe & Kramer, 2003; Kramer et al., 1999).

The mechanisms underlying improvement in cognitive tasks induced by yoga practice are not completely understood. It has been suggested that this effect arises from the improvement in mental concentration (Subramanya & Telles, 2009). Usually, yoga and similar practices are strongly related to increased levels of attention, as well as an improved ability to direct attention (Chiesa, Calati, & Serretti, 2011; Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). Indeed, attention improvements could lead to better performance in several kinds of cognitive tasks. This hypothesis seems to be corroborated by electrophysiological and imaging studies (Lakey, Berry, & Sellers, 2011; Slagter, Davidson, & Lutz, 2011).

From another standpoint, studies suggest that a memory task can be essentially a measure of inability to inhibit erroneous implicit recall, which would be related to hypothesis of unconscious thought theory. In other words, the involvement of conscious thought in solving a task would be not unequivocal, that is, a deliberation without conscious attention may occur when solving tasks (Dijksterhuis, Bos, Nordgren, & van Baaren, 2006). In this respect, since we used interference tasks between the trials in the short-term memory evaluation, it is possible that an unconscious deliberation occurred and this could have been the target for the improvement by yoga practice.

Alternatively, the effects of yoga practice in the psychophysiological parameters related to stress and general emotional health could have an indirect effect on cognition. Indeed, it has been shown that stress levels interfere with memory performance (Lupien, Maheu, Tu, Fiocco, & Schramek, 2007). For example, Elzinga and Roelofs (2005) verified that participants showed impaired working memory while performing a psychosocial stress during which both cortisol levels and sympathetic activity (heart rate and blood pressure) were elevated. Other study have demonstrated a correlation between the presence of high cortisol levels and impaired memory retrieval in healthy volunteers exposed to a social stressor (Buchanan & Tranel, 2008). In this respect, interventions based on mind–body techniques have been suggested as a strategy for transforming behavioral responses to life events (Astin, 1997). Further, increased anxiety is known to affect the performance on tasks

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requiring attention (Fox, 1993). Finally, although our study was conducted with healthy subjects, cognitive alterations are part of the symptoms of several psychiatric disorders, such as depression and anxiety (Hindmarch & Hashimoto, 2010; Mantella et al., 2007). In summary, the improvement in general mind and body health showed in this study and by other studies might account for a secondary amelioration in cognitive functions as a whole.

Finally, it is worth mention that three kinds of intervention were included in the yoga program applied in the study. This could be a limitation to possible conclusions of the effectiveness of each intervention (*pranaymas*, meditation or *asanas*), and further investigation with protocols focused in each technique would be of great interest. From another standpoint, most of the yoga classes attended by practitioners in the western include the three procedures. In this context, the present results contribute to the investigation of the effectiveness of the yoga program that would be usually available for the general population. On the other, it is also important to mention that the volunteers of the present study are probably different of the general population as regards the dedication to the program. Indeed, civilians are less likely to demonstrate the same adhesion in carrying out a task when compared to military individuals. As a consequence, the positive results of the practice might vary according to the regularity of attendance.

5. Conclusion

In conclusion, the data presented here indicate that yoga can effectively improve memory after 6 months of practice, along with psychophysiological measurements related to anxiety, depression and stress in healthy subjects. Regardless, although speculatively, we suggest that the results provide interesting starting evidence that yoga could be an effective treatment of anxiety, depression and stress, and their cognitive consequences. Nevertheless, the results generate at least possible applications at the preventive level. Additional studies with larger samples and longer periods of follow up would be of great interest to further corroborate these findings.

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References

Albuquerque, F. S., Barbosa, F. F., Leite, R. B. C., & Fuso, S. F. (2008). Effect of item repetition on episodic memory codification. *PSICO Porto Alegre PUCRS, 39*(3), 327–335.

Andrade, R. L., & Pedrão, L. J. (2005). Some considerations about nurses' use of non traditional therapies in psychiatric nursing care. *Revista Latino-Americana de Enfermagem, 13*(5), 737–742.

Ankad, R. B., Herur, A., Patil, S., Shashikala, G. V., & Chinagudi, S. (2011). Effect of shor-term pranayama and meditation on cardiovascular functions in healthy individuals. *Heart Views, 12*(2), 58–62.

Astin, J. A. (1997). Stress reduction through mindfulness meditation. *Psychotherapy and Psychosomatics, 66*, 97–106.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4*, 561–571.

Berger, B. G., & Owen, D. R. (1992). Mood alteration with yoga and swimming: Aerobic exercise may not be necessary. *Perceptual and Motor Skills, 75*(2), 1331–1343.

Biondi, M., & Picardi, A. (1999). Psychological stress and neuroendocrine function in humans: The last two decades of research. *Psychotherapy and Psychosomatics, 68*, 114–150.

Birdee, G. S., Yeh, G. Y., Wayne, P. M., Phillips, R. S., Davis, R. B., & Gardiner, P. (2009). Clinical applications of yoga for the pediatric population: A systematic review. *Academic Pediatrics, 9*(4), 212–220.

Buchanan, T. W., & Tranel, D. (2008). Stress and emotional memory retrieval: Effects of sex and cortisol response. *Neurobiology of Learning and Memory, 89*, 134–141.

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine, 31*, 23–33.

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review, 31*, 449–464.

Chiesa, A., & Serretti, A. (2009). A systematic review of neurobiological and clinical features of mindfulness meditations. *Psychological Medicine, 27*, 1–14.

Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: A meta-analytic study. *Psychological Science, 14*, 125–130.

Corwin, J. (1994). On measuring discrimination and response bias: Unequal numbers of targets and distractors and two classes of distractors. *Neuropsychology, 1*, 110–117.

Costa, M., Accioly, J. H., Oliveira, J., & Maia, E. (2007). Estresse: Diagnóstico dos policiais militares em uma cidade brasileira. *Revista Panamericana de Salud Pública, 21*(4), 217–222.

Cunha, J. A. (2001). *Manual da versão em português das. Escalas Beck*. São Paulo: Casa do Psicólogo.

Dijksterhuis, A., Bos, M. W., Nordgren, L. F., & van Baaren, R. B. (2006). On making the right choice: The deliberation-without-attention effect. *Science, 311*, 1005–1007.

Elsenbruch, S., Langhorst, J., Popkirowa, K., Müller, T., Luedtke, R., Franken, U., et al (2005). Effects of mind–body therapy on quality of life and neuroendocrine and cellular immune functions in patients with ulcerative colitis. *Psychotherapy and Psychosomatics, 74*, 277–287.

Elzinga, B. M., & Roelofs, K. (2005). Cortisol-induced impairments of working memory require acute sympathetic activation. *Behavioral Neuroscience, 119*(1), 98–103.

Evans, S., Cousins, L., Tsao, J. C., Subramanian, S., Sternlieb, B., & Zeltzer, L. K. (2011). A randomized controlled trial examining Iyengar yoga for young adults with rheumatoid arthritis: A study protocol. *Trials, 12*, 1–16.

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Fox, E. (1993). Attentional bias in anxiety: Selective or not? *Behaviour Research and Therapy, 31*, 487–493.
Gorenstein, C., & Andrade, L. (1996). Validation of a Portuguese version of the Beck Depression Inventory and the State-Trait Anxiety Inventory in Brazilian subjects. *Brazilian Journal of Medical and Biological Research, 29*(4), 453–457.
Grossman, P., Tiefenthaler-Gilmer, U., Raysz, A., & Kesper, U. (2007). Mindfulness training as an intervention for fibromyalgia: Evidence of postintervention and 2-year follow up benefits in well-being. *Psychotherapy and Psychosomatics, 76*, 226–233.
Hindmarch, I., & Hashimoto, K. (2010). Cognition and depression: The effects of fluvoxamine, a sigma-1 receptor agonist, reconsidered. *Human Psychopharmacology, 25*, 193–200.
Javnbakht, M., Hejazi, K. R., & Ghasemi, M. (2009). Effects of yoga on depression and anxiety of women. *Complementary Therapies in Clinical Practice, 15*(2), 102–104.
Jayasinghe, S. R. (2004). Yoga in cardiac health (a review). *European Journal of Cardiovascular Prevention and Rehabilitation, 11*, 369–375.
John, P. J., Sharma, N., Sharma, C. M., & Kankane, A. (2007). Effectiveness of yoga therapy in the treatment of migraine without aura: A randomized controlled trial. *Headache, 47*, 654–661.
Kramer, A. F., Hahn, S., Cohen, N. J., Banich, M. T., McAuley, E., Harrison, C. R., et al (1999). Ageing, fitness and neurocognitive function. *Nature, 400*, 418–419.
Kunz-Ebrecht, S. R., Mohamed-Ali, V., Feldman, P. J., Kirschbaum, C., & Steptoe, A. (2003). Cortisol responses to mild psychological stress are inversely associated with proinflammatory cytokines. *Brain, Behavior, and Immunity, 17*(5), 373–383.
Lakey, C. E., Berry, D. R., & Sellers, E. W. (2011). Manipulating attention via mindfulness induction improves P300-based brain–computer interface performance. *Journal of Neural Engineering, 8*, 1–7.
Lipp, M. (2000). *Manual do inventário de sintomas de Stress para adultos de Lipp*. São Paulo: Casa do Psicólogo.
Lupien, S. J., Maheu, F., Tu, M., Fiocco, A., & Schramek, T. E. (2007). The effects of stress and stress hormones on human cognition: Implication for the field of brain and cognition. *Brain and Cognition, 65*, 209–237.
Lutz, A., Greischar, L. L., Rawlings, N. B., Ricard, M., & Davidson, R. J. (2004). Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences of the United States of America, 101*, 16369–16373.
Mantella, R. C., Butters, M. A., Dew, M. A., Mulsant, B. H., Begley, A. E., Tracey, B., et al (2007). Cognitive impairment in late-life generalized anxiety disorder. *American Journal of Geriatric Psychiatry, 15*, 673–679.
Mastorakos, G., Pavlatou, M., Diamanti-Kandarakis, E., & Chrousos, G. P. (2005). Exercise and the stress system. *Hormones, 4*(2), 73–89.
Michalsen, A., Grossman, P., Acil, A., Langhorst, A., Ludtke, R., Esch, T., et al (2005). Rapid stress reduction and anxiolysis among distressed women as a consequence of a three-month intensive yoga program. *Medical Science Monitor, 11*(12), 555–561.
Nakao, M., Fricchione, G., Myers, P., Zuttermeister, P. C., Baim, M., Mandle, C. L., et al (2001). Anxiety is a good indicator for somatic symptom reduction through behavioral medicine intervention in a mind/body medicine clinic. *Psychotherapy and Psychosomatics, 70*, 50–57.
Oken, B. S., Zajdel, D., Kishiyama, S., Flegal, K., Dehen, C., Haas, M., et al (2006). Randomized, controlled, six-month trial of yoga in healthy seniors: Effects on cognition and quality of life. *Alternative Therapies in Health and Medicine, 12*(1), 40–47.
Pilkington, K., Kikwood, G., Rampes, H., & Richardson, J. (2005). Yoga for depression: The research evidence. *Journal of Affective Disorders, 89*, 13–24.
Rajesh, B., Jayachandran, D., Mohandas, G., & Radhakrishnan, K. (2006). A pilot study of a yoga meditation protocol for patients with medically refractory epilepsy. *Journal of Alternative and Complementary Medicine, 12*(4), 367–371.
Rangan, R., Nagendra, H., & Bhat, G. R. (2009). Effect of yogic education system and modern education system on memory. *International Journal of Yoga, 2*(2), 55–61.
Rani, K., Tiwari, S., Singh, U., Agrawal, G., Ghildiyal, A., & Srivastava, N. (2011). Impact of Yoga Nidra on psychological general wellbeing in patients with menstrual irregularities: A randomized controlled trial. *International Journal of Yoga, 4*, 20–25.
Ross, A., & Thomas, S. (2010). The health benefits of yoga and exercise: A review of comparison studies. *Journal of Alternative and Complementary Medicine, 16*(1), 3–12.
Sharma, V. K., Das, S., Mondal, S., Goswami, U., & Gandhi, A. (2006). Effect of Sahaj Yoga on neuro-cognitive functions in patients suffering from major depression. *Indian Journal of Physiology and Pharmacology, 50*(4), 375–383.
Slagter, H. A., Davidson, R. J., & Lutz, A. (2011). Mental training as a tool in the neuroscientific study of brain and cognitive plasticity. *Frontiers in Human Neuroscience, 10*, 5–17.
Smith, C., Hancock, H., Black-Mortimer, J., & Echert, K. (2007). A randomized comparative trial of yoga and relaxation to reduce stress and anxiety. *Complementary Therapies in Medicine, 15*(2), 77–83.
Subramanya, P., & Telles, S. (2009). Effect of two yoga-based relaxation techniques on memory scores and state anxiety. *BioPsychoSocial Medicine, 13*, 3–8.
Telles, S., Naveen, V. K., Balkrishna, A., & Kumar, S. (2010). Short term health impact of a yoga and diet change program on obesity. *Medical Science Monitor, 16*, 35–40.
Tsang, H. W., Chan, E. P., & Cheung, W. M. (2008). Effects of mindful and non-mindful exercises on people with depression: A systematic review. *British Journal of Clinical Psychology, 47*(3), 303–322.
Viru, A., & Viru, M. (2004). Cortisol – Essential adaptation hormone. *International Journal of Sports Medicine, 25*, 461–464.
West, J., Otte, C., Geher, K., Johnson, J., & Mohr, D. C. (2004). Effects of Hatha yoga and African dance on perceived stress, affect, and salivary cortisol. *Annals of Behavioral Medicine, 28*, 114–118.
Yogitha, B., Nagarathna, R., John, E., & Nagendra, H. (2010). Complimentary effect of yogic sound resonance relaxation technique in patients with common neck pain. *International Journal of Yoga, 3*, 18–25.
Yoshihara, K., Hiramoto, T., Sudo, N., & Kubo, C. (2011). Profile of mood states and stress-related biochemical indices in long-term yoga practitioners. *BioPsychoSocial Medicine, 5*, 6.
Yurkuran, M., Alp, A., Yurtkuran, M., & Dilek, K. (2007). A modified yoga-based exercise program in hemodialysis patients: A randomized controlled study. *Complementary Therapies in Medicine, 15*, 164–171.

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