



The effects of mind–body training on stress reduction, positive affect, and plasma catecholamines

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ABSTRACT

This study was designed to assess the association between stress, positive affect and catecholamine levels in meditation and control groups. The meditation group consisted of 67 subjects who regularly engaged in mind–body training of “Brain-Wave Vibration” and the control group consisted of 57 healthy subjects. Plasma catecholamine (norepinephrine (NE), epinephrine (E), and dopamine (DA)) levels were measured, and a modified form of the Stress Response Inventory (SRI-MF) and the Positive Affect and Negative Affect Scale (PANAS) were administered. The meditation group showed higher scores on positive affect ($p = .019$) and lower scores on stress ($p < .001$) compared with the control group. Plasma DA levels were also higher in the meditation ($p = .031$) than in the control group. The control group demonstrated a negative correlation between stress and positive affects ($r = -.408, p = .002$), whereas this correlation was not observed in the meditation group. The control group showed positive correlations between somatization and NE/E ($r = .267, p = .045$) and DA/E ($r = .271, p = .042$) ratios, whereas these correlations did not emerge in the meditation group. In conclusion, these results suggest that meditation as mind–body training is associated with lower stress, higher positive affect and higher plasma DA levels when comparing the meditation group with the control group. Thus, mind–body training may influence stress, positive affect and the sympathetic nervous system including DA activity.

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Various diseases have been associated with psychosocial or mental stress [1,8]. Meditation is one of the most well-known mind–body training methods which contribute to managing stress and enhancing mental and physical development. Research has shown that subjects who practiced meditation performed significantly better in tasks requiring attention and demonstrated greater reductions in stress than did a control group [22,25,30]. Meditation has been used in medical approaches to stress management and mental disorders. In addition, loving-kindness meditation, which facilitates the transformation of anger into compassion, was associated with significant reductions in pain and psychological distress [3]. Understanding of the mechanisms by which meditation practice affects stress and the body may be enhanced by measuring levels of plasma catecholamines, as these substances (norepinephrine

(NE), epinephrine (E), and dopamine (DA)) are released by the adrenal glands in response to stress [28]. In other words, levels of plasma catecholamines are related to levels of stress [21,28]. NE and DA, which are known to act as neuromodulators in the central nervous system, also play important roles in blood circulation as hormones interacting with several peripheral organs, including the heart, blood vessels and peripheral nervous system. Another study which used relative ratio of catecholamine also reported that a statistically significant difference of the NE/E ratio in a stress response was found to exist between the experimental and control groups in-flight stress of student pilots [19]. Therefore, measuring both absolute and relative values of catecholamine may be more helpful when studying about stress with catecholamine levels.

The experience of stress has been described primarily in terms of negative emotions, but evidence for the co-occurrence of positive and negative emotions during stressful periods has been accumulating [9]. It has been reported that both meditation and relaxation groups showed significant decreases in distress and increases in positive mood states over time compared with a con-

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trol group [15]. Moreover, spiritual meditation, which combines spiritual or religious intervention with meditation, was associated with greater reductions in anxiety, more positive mood states, enhanced spiritual health, and more numerous spiritual experiences than were secular meditation and relaxation [31]. Attentional and loving-kindness meditation were also associated with significant reductions in anxiety and negative affect [29] as well as with increases in positive emotions [10]. Peripheral DA levels were elevated while participants experienced positive emotions, such as those elicited by watching films featuring their favorite actors [23]. The implications of a more integrated view of the mind–body relationship have been discussed with respect to emotions and psychosomatic symptoms, the development of psychosomatic vulnerabilities, somatization, and alexithymia [24]. The mind is not based solely on brain structure and function, but on the continuous interaction of the brain with the body and the external world [11]. When a stressful stimulus arises from the external world, the stress itself is neutral, even though it has negative effects. Different behavioral and physiological coping styles in response to stress have been observed in animals [17]. Thus, the attitudes or coping strategies used by each individual to process stress seem to constitute critical factors in the regulation and state of the brain and body.

We hypothesized that the meditation and control groups have different levels of stress and positive/negative emotions. In addition, we measured plasma DA, NE and E, and compared the two groups in terms of absolute levels and relative ratios of these catecholamines. To understand the mechanisms by which meditation regulates stress, we examined whether the absolute levels and relative ratios of plasma catecholamines were correlated with measures of stress and positive/negative emotions.

All participants in the control and meditation groups voluntarily engaged in this research. The control group consisted of 57 healthy subjects, ages 19–37 (mean \pm SD: 25 \pm 4) years. The Structured Clinical Interview for DSM-IV Non-patient Version was used in assessing psychiatric disorders in participants. Exclusion criteria included a life time history of psychosis, bipolar disorder, major depressive disorder, substance abuse or dependence, significant head injury, seizure disorder, or mental retardation. The meditation group consisted of 67 subjects, aged 18–36 (mean \pm SD: 26 \pm 3) years, who practiced meditation regularly. Subjects in the meditation group had been practicing meditation for a mean of 43 months (range: 3–144 months). This study focused on subjects who were homogeneous in age and who practiced the same type of meditation. All subjects in the meditation group engaged in “Brain Wave Vibration” mind–body training, which is known to facilitate the process by which the negative thoughts that generate negative brain waves change into positive thoughts that generate positive brain waves. This process has also been described as brain respiration because it focuses primarily on the brain and its development, although the actual practice of this discipline resembles yoga, martial arts, and meditation. Brain Wave Vibration is a mind–body training technique designed to relax both mind and body through natural rhythmic movements. It is intended to be a simple meditation technique, a kind of moving meditation that can be used to manage stress and optimize brain health. This technique is designed to help quiet the thinking mind and release emotions, particularly negative emotions, through physical movements and focus on body sensations. The first step is to consciously move the body, starting by gently shaking the head to the left and to the right. The second step involves following one’s own natural rhythm and focusing on physical sensations and vibrations, which may spread to all parts of the body. Once the vibration becomes natural and familiar, practitioners reflexively engage in the third step, characterized by an increased awareness of the movement of energy within the body.

Thirteen subjects from a total sample of 80 meditation practitioners and 5 subjects from a total sample of 62 control participants did not respond to the Stress Response Inventory (SRI) or Positive Affect and Negative Affect Scale (PANAS) or did not answer at least one of each type question and were excluded from the total analysis. This experiment used 22 questions derived from the original SRI questionnaire [16]. Each question was scored on a Likert-type scale including “not at all” (0), “somewhat” (1), “moderately” (2), “very much” (3), or “absolutely” (4). The 22 questions were categorized into three simplified stress factors: somatization, depression, and anger [6].

The PANAS was used to measure positive and negative affects. This scale consists of 20 items describing different feelings and emotions in terms of 10 positive and 10 negative affective descriptors. Responses were scored on a five-point scale with higher scores indicating higher affect.

Blood samples were obtained from members of both the control and meditation groups at random times during the day. After subjects were seated, blood was collected in an anticoagulant EDTA tube. After centrifugation, the separated plasma was frozen at -80°C . The plasma levels of the catecholamines were determined with high-performance liquid chromatography. During the mobile phase, the mixture was prepared according to a predetermined proportion specified by Chromsystem. A mixture of NE, E, and DA was used at predetermined concentrations, as per the same company, as an external standard, and dihydroxybenzylamine was used as the internal standard. The plasma catecholamine analysis system marketed by Chromsystem was employed. A CLC-300 dosing pump with a flow rate of 1.1 ml/min was connected to a reverse-phase catecholamine C-80 (code no. 5100/K) column. A CLC-100 electrochemical detector was used, and its signal was registered and integrated by the Chromsystem Geminix registry and calculation terminal.

Plasma catecholamine levels for the control and meditation groups were analyzed by two different methods. The first method involved measuring the absolute quantity of NE, E, and DA, and the second involved analysis of the relative levels of these substances, yielding such data as the NE/E and DA/E ratios.

The Student’s *t*-test was used to analyze the differences between the two groups. Pearson’s correlation coefficient was used to analyze the relationship between two variables, and *p*-values less than .05 were considered statistically significant.

The meditation group obtained higher scores on positive affect ($p = .019$) and lower scores on stress ($p < .001$) compared to the control group (Fig. 1). The meditation group scored slightly lower than the control group on negative affect, but this difference did not reach statistical significance ($p = .089$). Plasma DA levels were higher in the meditation ($p = .031$) than in the control group (Fig. 1). The relationship between stress and positive or negative affect in both control and meditation groups was also investigated. The control group manifested a positive correlation between stress and negative affect ($r = .628$, $p < .001$) and a negative correlation between stress and positive affect ($r = -.408$, $p = .002$) (Fig. 2). The meditation group demonstrated a positive correlation between stress and negative affect ($r = .460$, $p < .001$), but did not exhibit a negative correlation between stress and positive affect ($r = -.196$, $p = .113$) (Fig. 2). There were no correlations between positive affect and plasma DA levels for the meditation or control group. A post hoc test including only the 24 subjects that had practiced meditation 48 months or more, showed a positive correlation between positive affect and plasma DA levels ($r = .501$, $p = .013$). Stress factors such as somatization ($p < .001$), depression ($p < .001$) and anger ($p < .001$) were lower in the meditation group compared to the control group. The control group demonstrated a negative correlation between stress and positive affect ($r = -.408$, $p = .002$), but the meditation group did not demonstrate a significant correlation

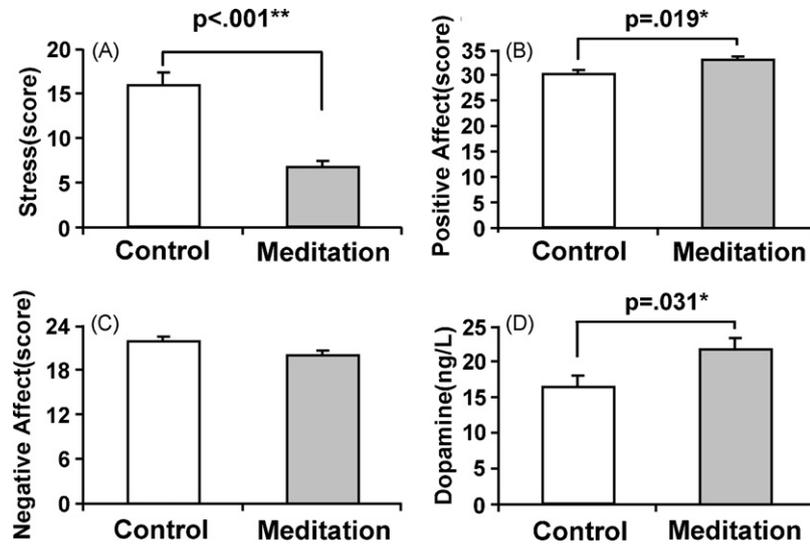


Fig. 1. Stress (A), positive affect (B), negative affect (C), and plasma dopamine levels (D) in the control ($n=57$) and meditation ($n=67$) groups (A–D), $p=p$ -value.

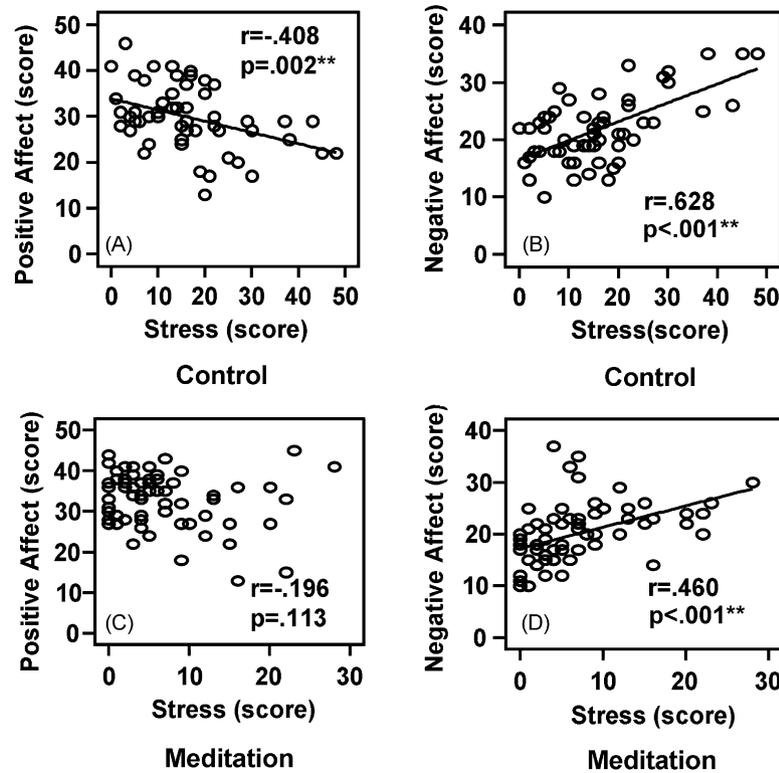


Fig. 2. Correlations between stress and positive or negative affect in the control and meditation groups. (A and B) Control group: $n=57$. (C and D) Meditation group: $n=67$. (A–D) r = Pearson's correlation coefficients, $p=p$ -value.

Table 1
Correlations between stress factors and positive and negative affect or NE/E and DA/E ratios.

Stress factors	Control group ($n=57$)			Meditation group ($n=67$)		
	Somatization	Depression	Anger	Somatization	Depression	Anger
Positive affect	$r=-.360^{**}$	$r=-.477^{**}$	$r=-.032$	$r=-.069$	$r=-.299^*$	$r=-.148$
Negative affect	$r=.561^{**}$	$r=.509^{**}$	$r=.492^{**}$	$r=.508^{**}$	$r=.280^*$	$r=.389^{**}$
NE/E ratio	$r=.267^*$	$r=.096$	$r=-.052$	$r=-.077$	$r=-.074$	$r=-.009$
DA/E ratio	$r=.271^*$	$r=.162$	$r=-.023$	$r=-.045$	$r=-.037$	$r=.052$

r = Pearson's correlation coefficients.

* $p < 0.05$.

** $p < 0.01$

between somatization and positive affect (Table 1). The control group showed positive correlations between somatization and NE/E ($r = .267, p = .045$) and DA/E ($r = .271, p = .042$) ratios, whereas these correlations did not emerge in the meditation group (Table 1).

In this study, the meditation group exhibited lower stress and higher positive affect compared to the control group. Moreover, plasma DA levels were significantly higher in the meditation than in the control group, but there were no group differences for NE and E. A previous study with 35 subjects (19 meditators and 16 controls) could not find differences between the meditation and control group in plasma DA [14]. Thus, this is the first study showing higher plasma DA levels in the meditation group compared to the control group. Our findings of lower stress and higher positive affect in the meditation group compared to the control group are consistent with those of previous reports [3,15]. However, our finding that stress did not correlate with positive affect in the meditation group (Fig. 2C), as it did in the control group (Fig. 2A), requires further study.

Furthermore, positive psychological states or traits have been related to reduction in hypothalamic–pituitary–adrenal (HPA) reactivity [5]. Thus, we propose that the increase in positive emotions emerging from mind–body training results in the reduction of HPA reactivity via the regulation of stress. Neurochemical and neuroanatomical studies supporting positive mood effects mediated by dopamine indicates that even mild fluctuations in positive and negative moods can have a significant influence on neural activation and cognitive processes [2,26]. Considering that peripheral DA levels were also elevated while participants experienced positive emotions [23], the high plasma DA levels in the meditation group are thought to be associated with high positive affect as the effects of mind–body training. However, given that a post hoc test including only the 24 subjects that had practiced meditation 48 months or more, showed the positive correlation between positive affect and plasma DA levels, the duration of mind–body training seems to contribute to significant elevation of plasma DA levels. Thus, high positive affect and low stress through mind–body training may influence the sympathetic nervous system including DA activity.

A previous study using the Symptom Checklist reported that a meditation group experienced greater symptom reduction, including somatization, than did a control group [12]. In our study, the control group demonstrated positive correlations between somatization and the NE/E or DA/E ratio and a negative correlation between somatization and positive affect. On the other hand, the meditation group did not show correlations between the NE/E or DA/E ratio and somatization. That is, positive affect, which may control or regulate stress, seems to attenuate the association between somatization and the NE/E or DA/E ratio as a result of mind–body training (Table 1). Although the causes of somatization symptoms remain unclear, the possibility that certain dysfunctional connections between the mind and the body contribute to psychological stress has been discussed, and psychosomatic medicine [24] has provided novel alternative approaches to reducing physical and psychological symptoms [7,27]. In addition, interventions based on cognitive–behavioral constructs or meditation can increase positive emotional states to enhance health and prevent disease [4]. In this study, the absolute levels of plasma DA and positive affect scores were higher, and stress scores were lower, in the meditation group compared to the control group (Fig. 1). Higher plasma DA levels in the meditation group may imply that HPA axis or sympathetic nervous system might be involved in underlying mechanism of mind–body training [13]. This notion is supported by a study reporting increased striatal DA release during meditation [18].

The strength of this study is the relative high number of subjects, and that the subjects were homogeneous in age and in the particular type of meditation they practiced. However, there

are some limitations in this study. Although positive correlations between cerebrospinal fluid and plasma catecholamines have been reported [23], the functions of catecholamines in the central and peripheral nervous systems are different from the functions of peripheral catecholamines. Thus, the dynamic functions of catecholamines in both the central and peripheral nervous systems during mind–body training require examination in a future study. The cross-sectional design used in this research is another limitation. The novel findings in this study needs to be replicated using similar measures before and after the meditation or mind–body training.

In conclusion, meditation as mind–body training may be associated with lower stress and higher positive affect. The higher plasma DA levels observed in the meditation group when compared to the control group might be related to the higher positive affect and lower stress observed in the meditation group. Thus, mind–body training may influence stress, positive affect and the sympathetic nervous system including DA activity. Our present knowledge of the mechanisms underlying the interactions between mind and body is insufficient, and further research in this field is needed.

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