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·Review·

Mechanism of Integrative Body-Mind Training

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Abstract: Integrative Body-Mind Training (IBMT) originates from ancient Eastern tradition. The method stresses no effort to control thoughts, but instead a state of restful alertness that allows a high degree of awareness of the body, breathing, and external instructions. A series of studies indicates that IBMT improves attention and self-regulation through interaction between the central (brain) and the autonomic (body) nervous systems. The present review mainly summarizes the recent results of IBMT studies and proposes how it changes the state of brain and body to lead to positive outcomes. Future directions in this field are also discussed.

Keywords: Integrative Body-Mind Training; neuroplasticity; autonomic nervous system; central nervous system

1 Introduction

Integrative Body-Mind Training (IBMT) originates from ancient Eastern tradition. The IBMT method is based on traditional Chinese medicine combined with the latest neuroscience findings[1]. It was developed in the 1990s, and its effects have been studied in China since 1995. Based on the results from hundreds of adults and children ranging from 4 to 90 years old in China, IBMT practice has been shown to improve attention and self-regulation[1-10].

IBMT involves body relaxation, mental imagery, and mindfulness training, accompanied by selected background music. It achieves the desired state by “initial mind setting” with a brief period of instructions, to induce a cognitive or emotional set that will influence the training. The method does not stress the control of thoughts, but instead provides a state of restful alertness that allows a high degree of awareness of the body, breathing, and external instructions (usually from a compact disc). IBMT stresses a balanced state of relaxation while focusing on attention. Thought control is achieved gradually through posture and relaxation, body-mind harmony, and balance with the help of the coach rather than by making the trainee attempt an internal struggle to control thoughts in accordance with instructions[1-10].

2 IBMT improves attention and reduces stress

In our study of IBMT training effects, IBMT was applied to a randomly-selected group of Chinese undergraduates, while the control group was given the same amount of muscle relaxation training that is very popular in the West[4]. A standard computerized attention test (Attention Network Test, ANT)[11] that measures orienting, alerting, and the ability to resolve conflict (executive attention) was then given to the subjects. Five days of IBMT 20 min/day) showed a significantly greater improvement than the control group on the ANT “resolution of conflict” score. Furthermore, the Profile of Mood States measured before and after training revealed less anxiety, depression, anger and fatigue, as well as greater vigor in subjects

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receiving IBMT training, indicating that short-term IBMT can enhance positive and reduce negative mood. We also tested the hypothesis that improvement in the efficiency of attention accompanies higher intelligence scores by using Raven's Standard Progressive Matrices, a standard and culturally-balanced measure of general intelligence. The results revealed that short-term IBMT improves the Raven's score, although only marginally more so than in the control group[4]. Finally, if the ability to self-regulate emotion and cognition improves in the training group, members of the group should also show reduced reactions to stress as measured by, for example, cortisol levels and immunoreactivity. Cortisol and sIgA are indexes of the amount of stress induced by a cognitive challenge. We applied 3 min of mental arithmetic as an acute stress after 5-day IBMT or relaxation. Compared to the relaxation group, the IBMT group showed a significant decrease in stress-related cortisol, and an increase in immunoreactivity (see ref. 4 for details of the above experiments).

3 Brain-body interaction during IBMT

Our previous study showed that 5-day IBMT improves attention and self-regulation compared with the same amount of relaxation training, so the underlying mechanisms were then investigated. Cooperation between body and mind is emphasized in facilitating and achieving a meditative state in IBMT practice, so in the following study, we tested the role of body (physiology)-mind (brain) interaction and balance in the effect of IBMT. In that study, 46 Chinese undergraduates were randomized into experimental (IBMT) and control (relaxation) groups, and underwent brain imaging (regional cerebral blood-flow) with physiological measures, whereas another 40 participants were also randomly assigned into IBMT and relaxation groups, but received electroencephalography (EEG) with physiological measures. The physiological measures were heart rate, skin conductance response (SCR), and respiratory rate and amplitude, to monitor autonomic nervous system activity. Measurements were made at rest before, during, and after 5 d of IBMT or relaxation training[5]. During and after training, the IBMT group showed significantly better physiological reactions in heart rate, respiratory amplitude and rate, and SCR than the relaxation controls. Differences in heart rate variability (HRV) and EEG power suggested greater involvement of the autonomic nervous system (especially parasympathetic activity) in the IBMT group during and after training; imaging data demonstrated stronger subgenual and adjacent ventral anterior cingulate cortex (ACC) activity in the IBMT group; and frontal midline (FCz) ACC theta also correlated with high-frequency HRV, suggesting control by the ACC over parasympathetic activity (see ref. 5 for further details).

These findings indicate that after 5 d of training, the IBMT group show improved regulation of the autonomic nervous system by a ventral midfrontal brain system than the relaxation group. This enhancement probably reflects training in the coordination and balance of body and mind by IBMT but not by relaxation training. These results could be useful in the design of further specific interventions[5]. Based on these results, the "state-change hypothesis" was proposed to further explain the IBMT mechanism of central and autonomic nervous interaction and balance[10]. State-change refers to the shift between certain forms of experience such as sleepiness or wakefulness and meditation or exercise. These experiences have in common an altered state of mind and body. IBMT improves attention and self-regulation through state changes involving both body and mind. The combined use of body and mind training is supported by studies of embodied cognition, in which changes in the body, particularly in facial expression, influence emotional processing, facilitate the retrieval of autobiographical memories and enhance the sense of power[12-14].

4 IBMT induces neuroplasticity

Months of motor learning or working memory training in adults are known to induce experience-dependent structural changes in the gray matter associated with task demand[15-17]. However, whether or when mindfulness training produces similar changes is largely unknown. We first tested this hypothesis using voxel-based morphometry analysis with the FMRIB Software Library (FSL) tools, and revealed that 2 weeks of consecutive IBMT practice or relaxation training produce no significant changes in gray matter[18], suggesting that longer training is required.

Recently, we reported that 11 h of IBMT over a 4-week period improves the efficiency of executive attention and alerting attention networks[1]. IBMT also improves the basal immune system in a “dose-dependent” manner within the range of training for between 3 h (over a 5-day period) and 11 h[19]. Based on this evidence, we hypothesized that 11 h of IBMT training over 1 month would induce structural changes associated with the ACC self-regulation networks.

To test this hypothesis, we randomized 45 undergraduates into IBMT and relaxation groups for 11 h of training, 30 min per session over a month. Before and after training, brain images were acquired from each participant at rest for analysis of white matter by diffusion tensor imaging, and of gray matter by voxel-based morphometry. No areas showed significant changes in gray and white matter after 11 h of relaxation training. However, we found significant changes in fractional anisotropy, an index of the integrity and efficiency of white matter, in the anterior corona radiata, an important white matter tract connecting the ACC, a key node in the self-regulation network[6] (see ref. 6 for details).

Because deficits in activation of the ACC are associated with many disorders[20-23], the ability to strengthen cingulate connectivity through training could provide a means for improving self-regulation and serve as a possible therapy or prevention tool[6]. Further, these findings suggest using IBMT as a vehicle for understanding how training influences the brain plasticity observed in functional activation, functional connectivity, white matter anisotropy, EEG coherence, gray matter volume, and other measures. Further research is required to replicate them in a large sample size, and to test whether longer training induces gray matter neuroplasticity.

5 Why ACC in IBMT practice?

Recently, mind-body interventions or mindfulness-based interventions have been studied[24-31]. The mental processes of these interventions require paying attention and self-regulation, so it is reasonable to assume that the underlying neural mechanisms may share brain regions and networks with the mental process. Previous studies have shown activation of a large overlapping network of attention-related brain regions such as prefrontal, midfrontal, ACC and parietal cortex during long-term mindfulness training[31-33]. However, problems of subtle differences between control and experimental groups remain in these studies, because the two groups were not completely randomly assigned, and meditators differed greatly in the style of meditation and the duration of previous practice. Thus, the random assignment of participants to conditions during short-term training such as IBMT is required to confirm these findings[5-10].

Attention involves three more specialized networks that carry out the functions of alerting, orienting and executive control[34]. The attentional networks, especially the executive control network, play a key role in resolving conflicting thoughts and thus maintaining a tranquil state in a restless mind[4,5,10].

What do the perception of pain, either physical[35] or social[36], processing of reward[37], monitoring of conflict[38], error detection[39], and theory of mind[40] all have in common? They all activate an area of midfrontal cortex that includes the ACC. A further question is whether there is a single function that requires all of these input signals. It has been argued that this brain area regulates the processing of information from other networks, serving as part of an executive attention network involved in the control of both cognition and emotion[9,10,34]. Executive attention is a network that includes the ACC and in adults is often activated by requiring a person to withhold a dominant response in order to perform a subdominant one[34,41]. In developmental psychology, the ability of a person to control thoughts, feelings, and behavior is called self-regulation. The self-regulatory view helps us to understand how brain networks relate to important real-life functions[41].

Self-regulation is a natural function of networks, acting to control the influx of information from the environment through orienting, in order to avoid conflicting responses in behavior[43]. For example, in the Stroop effect, word-reading is a highly overlearned response that must be ignored in order to respond to the conflicting ink color. Neuroimaging provides strong evidence that conflict tasks like the Stroop effect activate common areas of the ACC[38,42,43]. Support for the voluntary exercise of self-regulation comes from studies that examine either the instruction to control affect or the connections involved in the exercise of that control, which reveal activation in mid-frontal and cingulate areas[44,45]. If participants are required to select an input modality, the cingulate shows functional connectivity to the selected sensory system[46]. Similarly, when involved in emotional processing, the cingulate shows functional connections to limbic areas[47]. These findings support the role of cingulate areas in the control of cognition and emotion. There is also evidence for anatomical connectivity between the ventral cingulate and limbic areas and the dorsal cingulate, parietal, and frontal areas[48].

Taking these together, we argue that the ACC plays an important role in executive function and self-regulation during meditation practice[5,6,9,34,41].

Why is prefrontal cortex (PFC) activation not found in IBMT practice? One explanation is that IBMT practice stresses no effort to control thoughts, but instead a state of restful alertness that allows a high degree of awareness of the body, breathing, and external instructions[1-6]. This effortless practice mainly involves ACC activity rather than the effortful control and demand in which requires the PFC to maintain the meditative state, which is consistent with the transient hypofrontality hypothesis supported by neuroimaging results of decreased PFC activity during meditation and spontaneous improvisation[49-51]. In contrast, stronger PFC activation is detected in meditation if the practitioners are required to exert strong control over attention and thoughts to maintain the meditative state[29-31]. Further research warrants the exploration of the PFC-ACC relationship during meditative states using different neuroimaging techniques such as fMRI functional connectivity, voxel-based morphometry, cortical thickness and diffusion tensor imaging, which can be used to explore the neural mechanisms of meditation[29-31,52,53].

6 Future directions

Although meditation studies draw much attention and have demonstrated training effects and their underlying neural mechanisms, the neuroscientific study of meditation is still in its infancy. These findings need to be supplemented with more data, most crucially from longitudinal studies examining changes over time within the same individuals randomized either to meditation training or to an active control group.

Future work is required to address at least the following questions:

Which factors help and facilitate meditation? (These may include appropriate attention and effort, optimal body-mind states, attitude and motivation.) What is the critical period (i.e. age or duration of training) for this practice? What are the critical ages (if any) for this training to achieve its greatest impact? What is the optimal “dose” of particular types of meditation at different ages? How can individual differences be matched to different meditation methods? How do gene-environment interactions affect practice? What are the peripheral biological consequences of different forms of meditation? What are the relationships between meditation and other states such as flow and awareness?

In summary, IBMT improves attention and self-regulation through interaction between the central (brain) and the autonomic (body) nervous systems. IBMT changes the state of brain and body to lead to positive outcomes in emotion, cognition and behavior. IBMT practice needs an open mind, patience and acceptance. It is an experiential learning journey. Future research will help uncover the underlying mechanisms and enhance this type of mental training.

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整体身心调节法的机理

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摘要：整体身心调节法源于东方身心科学，并结合了现代脑科学的最新发现。系列研究表明，整体身心调节法通过中枢和自主神经系统的相互作用，可以提高注意力和自我调节能力，具有降低压力、保持健康和提高表现等作用。本文概述了整体身心调节法的近期研究成果，提出状态改变机制，同时对未来本领域的发展趋势进行展望。

关键词：整体身心调节法；神经可塑性；自主神经系统；中枢神经系统