International Journal of Psychophysiology 89 (2013) 305–313

Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

Mindfulness meditation, well-being, and heart rate variability: A preliminary investigation into the impact of intensive Vipassana meditation

Jonathan R. Krygier [a,b], James A.J. Heathers [b], Sara Shahrestani [a,c], Maree Abbott [b], James J. Gross [d], Andrew H. Kemp [a,b,e,f,*]

[a] *SCAN Research & Teaching Unit, School of Psychology, University of Sydney, Australia*
[b] *School of Psychology, University of Sydney, Australia*
[c] *Brain and Mind Research Institute, University of Sydney, Australia*
[d] *Department of Psychology, Stanford University, USA*
[e] *CADE Clinic, Discipline of Psychiatry, Sydney Medical School, University of Sydney, Australia*
[f] *Hospital Universitaìrio, University of São Paulo, Brazil*

ARTICLE INFO

Article history:
Received 14 February 2013
Received in revised form 12 June 2013
Accepted 14 June 2013
Available online 22 June 2013

Keywords:
Meditation
Mindfulness
Vipassana
Heart rate variability
Well-being
Respiratory sinus arrhythmia
Traube–Hering–Mayer waves

ABSTRACT

Mindfulness meditation has beneficial effects on brain and body, yet the impact of Vipassana, a type of mindfulness meditation, on heart rate variability (HRV) – a psychophysiological marker of mental and physical health – is unknown. We hypothesised increases in measures of well-being and HRV, and decreases in ill-being after training in Vipassana compared to before (time effects), during the meditation task compared to resting baseline (task effects), and a time by task interaction with more pronounced differences between tasks after Vipassana training. HRV (5-minute resting baseline vs. 5-minute meditation) was collected from 36 participants before and after they completed a 10-day intensive Vipassana retreat. Changes in three frequency-domain measures of HRV were analysed using 2 (Time; pre- vs. post-Vipassana) × 2 (Task; resting baseline vs. meditation) within subjects ANOVA. These measures were: normalised high-frequency power (HF n.u.), a widely used biomarker of parasympathetic activity; log-transformed high frequency power (ln HF), a measure of RSA and required to interpret normalised HF; and Traube–Hering–Mayer waves (THM), a component of the low frequency spectrum linked to baroreflex outflow. As expected, participants showed significantly increased well-being, and decreased ill-being. ln HF increased overall during meditation compared to resting baseline, while there was a time ∗ task interaction for THM. Further testing revealed that pre-Vipassana only ln HF increased during meditation (vs. resting baseline), consistent with a change in respiration. Post-Vipassana, the meditation task increased HF n.u. and decreased THM compared to resting baseline, suggesting post-Vipassana task-related changes are characterised by a decrease in absolute LF power, not parasympathetic-mediated increases in HF power. Such baroreflex changes are classically associated with attentional load, and our results are interpreted in light of the concept of 'flow' — a state of positive and full immersion in an activity. These results are also consistent with changes in normalised HRV reported in other meditation studies.

1. Introduction

In the last two decades, psychological interventions derived from mindfulness meditation practices have been increasingly used to treat a variety of stress, pain and anxiety-related conditions (Hofmann et al., 2010). Mindfulness refers to the state of being attentive to and aware of what is taking place in the present (Brown and Ryan, 2003; Shapiro, 2009); mindfulness meditation comprises a variety of techniques that help focus attention in a non-analytical way and avoid discursive, persistent, or obsessive thoughts (Shapiro, 1980). These techniques – such as quieting the mind, and exercising self-control – can have a profound influence on mind and body, and show promise as an alternative tool to regulate emotions, mood, and stress. However, the acute and longer-term concomitants of mindfulness meditation training, and potential mechanisms of action are still not well understood. In particular, there is a need to further understand the effects of meditation on the autonomic nervous system, a major component of emotional experience. While limited research has examined the effects of Zen meditation, different styles may have distinctive effects. For instance, Zen meditators show distinctive respiration changes (Lehrer et al., 1999) that are not evident in other styles such as yoga (Sarang and Telles, 2006) or traditional

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* Corresponding author at: Centro de Pesquisa Clínica e Epidemiológica, Hospital Universitário, Universidade de São Paulo, Av Lineu Prestes 2565, 05508-000 São Paulo, SP, Brazil. Tel.: +55 11 3091 9300x9241.
E-mail address: andrew.kemp@sydney.edu.au (A.H. Kemp).

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http://dx.doi.org/10.1016/j.ijpsycho.2013.06.017

Chinese practices (Tang et al., 2009). Here we examine the impact of a particularly intensive form of mindfulness meditation – Vipassana – on heart rate variability, an important psychophysiological marker of mental health and wellbeing.

1.1. Meditation and well-being

One of the goals of mindfulness is to allow thoughts to arise, be examined dispassionately, and allowed to fade, without practitioners being emotionally influenced by their contents. This process is a fundamental part of Vipassana meditation (Gethin, 1998). This technique is also similar to the reappraisal strategy for emotion regulation, which can serve to decrease subjective, physiological and neural responses, rather than increasing them as is the case with emotion suppression (Gross and Levenson, 1997; Gross, 1998; Goldin et al., 2008).

Mindfulness techniques appear to be linked in a variety of ways to well-being. Important behavioural examples include reduction in distractive and ruminative thinking (Jain et al., 2007) and symptoms of anxiety and mood disorders (Goldin and Gross, 2010; Hofmann et al., 2010), and improved emotion regulation (Arch and Craske, 2006). Individual differences in the ability to regulate emotional responses are also related to differences in mindfulness, even in non-meditators (Modinos et al., 2010). These findings suggest the possibility that mindfulness meditation influences well-being via changes in emotion regulation. Furthermore, trait mindfulness was associated with wider prefrontal and diminished amygdale activity during an affect labelling task in non-meditators, suggesting a possible mechanism for the role of mindfulness in emotion regulation (Creswell et al., 2007).

Neural and physiological benefits found to be associated with meditation include: increases in immune system activity and left-sided anterior activation, a pattern associated with positive affect (Davidson et al., 2003); decreased amygdale response to emotional stimuli (Desbordes et al., 2012) and increased brain connectivity (Luders et al., 2011). Moreover, long-term meditators had greater grey matter density in regions previously found to be involved in meditation including right anterior insula (involved in interoceptive awareness), left inferior temporal gyrus and right hippocampus and right orbito-frontal cortex (Hölzel et al., 2008; Luders et al., 2009). These particular studies are relevant because of the overlap with regions of the central autonomic network related to heart rate variability, especially insular and orbitofrontal cortices (Thayer and Lane, 2000; Thayer et al., 2009). Experienced meditators demonstrated increased cortical thickness in insula and prefrontal cortices compared to matched controls (Lazar et al., 2005), as well as larger gyrification in regions including left precentral and right fusiform gyrii, and the insula (Luders et al., 2012). These findings, taken together, suggest that meditation has dramatic long-term structural effects on the brain.

Vipassana is a widespread technique of mindfulness meditation, derived from Buddhist practice, based on objective observation of physical sensations in the body. Awareness of the breath is also used as an aid to concentration. It is taught in a standardised manner throughout the world, and involves up to 100 h of intense meditative practice over a 10-day period. This intense standardised training is ideally suited to examining the effects of mindfulness meditation on well-being and related physiological changes.

1.2. Well-being and heart rate variability

Heart rate variability (HRV) is a measure of beat-to-beat variability in heart rate that is mediated by the autonomic nervous systems. Parasympathetic influence on HRV is primarily mediated by the vagus nerve, which can provoke rapid changes from cardiac cycle to cardiac cycle, and is primarily responsible for fluctuations in respiratory sinus arrhythmia (RSA) and high frequency HRV (HF) (Dexter et al., 1992; Berntson et al., 1993). Sympathetic influence is primarily controlled by release of norepinephrine and catecholamines, precluding direct manifestation in short term fluctuations (Berntson et al., 1993) Sympathetic neural activity can alter cardiac behaviour only slightly from beat to beat (Levy et al., 1993), and thus RSA measured through HF HRV is often used as a biomarker of pure PNS activity. That is, the level of vagal outflow will be reflected in the magnitude of RSA, which is typically measured at the speed of normal breathing, at cycles from approximately 3 to 7 s (i.e. 0.15–0.4 Hz). THM, on the other hand is component of low frequency (LF) HRV which reflects an oscillation of arterial pressure (Julien, 2006). Recent studies suggest that low frequency power more closely approximates baroreflex outflow, rather than sympathetic activation (Moak et al., 2009; Goldstein et al., 2011).

Amongst other things, HRV reflects the capacity of the central autonomic network (CAN) – including the prefrontal cortex, central nucleus of the amygdala, hypothalamus and brainstem – to meet and adapt to environmental demands (Thayer and Friedman, 2002). HRV underpins an individual's capacity to regulate their emotions (Geisler et al., 2010), and may be key to psychological flexibility (Kashdan and Rottenberg, 2010).

HRV is reduced in patients with cardiovascular disease (Nolan et al., 1996), and reduced HRV is an indicator of risk of cardiac and all-cause mortality (Dekker et al., 2000; Tsuji et al., 1996). A number of studies and reviews (e.g. Kemp et al., 2010; Kemp et al., 2012) have indicated that HRV is reduced in patients with depression and anxiety, even without cardiovascular disease. While studies have often focused on links between decreased HRV, negative emotions and poor physical health, increased HRV is related to well-being (Kemp and Quintana, 2013–in this issue) over and above reductions in negative affect (Boehm and Kubzansky, 2012). There is growing evidence that positive psychological attributes such as mindfulness are independently related to cardiac health and autonomic function (DuBois et al., 2012), including individual differences in resting respiratory sinus arrhythmia (RSA) (Oveis et al., 2009) and THM (Fuller, 1992).

1.3. Meditation and HRV

The effects of Vipassana on HRV have not to our knowledge been systematically researched, although several other mindfulness based meditation techniques have been examined in more detail in novice and experienced meditators.

The acute task-related cardiovascular effects of Zen meditation compared to resting baseline in practitioners with varying levels of experience have been better studied than Vipassana. Lehrer et al. (1999) found that respiration rates fell dramatically during Zen breathing meditation in experienced meditation practitioners. High frequency (HF) HRV decreased as a percentage of total variance (although there were no significant changes for absolute HF power). Total heart rate (HR) oscillation amplitude increased, as did absolute low frequency (LF) power — reflecting a shift in RSA towards lower-frequency waves. These findings confirmed that Zen breathing meditation results in an increase in low and very low frequency HR oscillations, shifting the majority of HRV spectral power into the low frequency band. Within-subjects shifts in RSA during Zen meditation compared to resting baseline varied with experience (Peressutti et al., 2010). Strong HF oscillations were observed in novices; while for the most experienced practitioners, variance centred in the LF range and was linked to RSA, being associated with decreased breathing rate during meditation (Peressutti et al., 2012).

Much of this research focused on meditation tasks involves slow breathing, relative to a normal breathing condition during a resting baseline. Very different task effects were found for an inward-directed attention meditation task which did not involve controlled respiration. During this task experienced Zen meditators exhibited increases in normalised HF (HF n.u.) and corresponding decreases in normalised LF and LF/HF ratio, compared to resting non-meditators and to their own resting baseline (Wu and Lo, 2008). A number of studies have reported similar acute HF increases after other styles of meditation,