The Impacts of Mindfulness on Heart Rate Variability: A Brief Review

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Abstract—Background: Mindfulness is a famous program that has been practiced in the world for many years, its positive functions on human well-being have been proved. Its influences on central nervous system also have been studied using electroencephalography (EEG) and functional magnetic resource image. In recent years, some studies work on its action on autonomic nervous system using Heart Rate Variability (HRV). Objective: The major goal of this study is to evaluate the impacts of mindfulness on HRV based on literature review. Methods: We search for related papers from PubMed in recent 10 years which were published in English, and examine the effectiveness of HRV on the evaluation of mindfulness. Results: Most of results showed that time-domain based SDNN, RMSDD and frequency-domain based HF were significantly increased after 8-week mindfulness training. Conclusions: HRV metrics can be useful indices for the evaluation of mindfulness studies. It proved that increased SDNN, RMSDD and HF were associated with better parasympathetic function and well-being.

Index Terms—heart rate variability, mindfulness

I. INTRODUCTION

In recent decades, mindfulness has become popular keywords related distress reduction. Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT) are two famous programs which have standardized 8 weeks training course and online learning websites. Depending on them, many mindfulness programs have developed and widely used all over the world, at same time, many studies focus on Mindfulness-Based Interventions (MBIs) because of its positive effect on human health.

MBIs have been proved its positive effects in reducing stress, relieving anxiety, preventing depression and improving quality of life of healthy individuals [1], similar effects also showed in cancer patients [2]. It also works on some difficult treatment condition, such as Interstitial Cystitis, Bladder Pain Syndrome and lower back pain etc. [3], [4].

Although many studies have positive reports for MBIs group especial when the control group is non-MBIs or usual care group, some studies report no significant difference or only short-term effect when MBIs group was compared with maintain treatment group [5], and lack of long-term positive results [6].

Because that not all studies showed the positive efficiency of MBIs, it is necessary to study physiological and biological mechanisms of mindfulness. Compared with traditional scales and questionnaires, physiological biomarkers might provide more scientific evaluations. Many medical devices, such as electroencephalography (EEG), Functional Magnetic Resource Image (fMRI) and electrocardiography (ECG) can provide physiological data for clinical disease diagnosis and evaluation, they also have been used in research for many years.

Using EEG in mindfulness studies, results show that mindfulness is associated with increased alpha and theta brain wave power [7], positive related to attentional performance and cognitive flexibility [8]. Studies with fMRI provide evidences that mindfulness practices alter intrinsic functional connectivity in brain network, might enhance self-referential processes, can reflect more consistent attention focus and awareness of sensory [9], meditation related anxiety relief is associated with special brain cortex activity [10]. All of above demonstrate the impacts of mindfulness on Central Nerve System (CNS).

Theoretically, the action of mindfulness on CNS can influence on Autonomic Nervous System (ANS). As a well-known tool for assessing ANS, heart rate variability (HRV) can be an effective tool to evaluate the impacts of mindfulness on ANS.

ECG is a recording of electrical activity of heart beats. HRV is an analysis the time differences of every R-R interval of ECG. Usually, we adopt HRV with metrics of time-domain and frequency domain to evaluate the ANS dynamic function.

Studies showed that mindfulness practices increased the High Frequency power (HF) and decreased Low Frequency power (LF) and Low Frequency to High
Frequency ratio (LF/HF) [11], and different mindfulness states may produce different HRV condition [12]. Although more and more mindfulness studies have been documented and showed the influences on HRV, there is still lack of consensus. In this study, we aimed to search for related papers and discuss consistency of results.

II. METHOD

A. Research Design

We use literature analysis and content analysis in this study. Its purpose is to collect relevant literatures about the impacts of mindfulness on HRV. We compare and generalize the literatures through content analysis.

In our study, we search literatures on PubMed, the collected papers were limited by published in English and by 10 years before April, 2018.

We use mindfulness and heart rate variability as keyword to search related papers. Those papers studying about the effects of MBIs on HRV metrics will be included.

In our study, we use frequently-used HRV metrics, such as standard deviation of all normal to normal intervals (SDNN), standard deviation of R-R interval (SDRR), standard deviation of the average of NN intervals in all 5-minute segments of the entire recording (SDANN), SDNN Index (SDNNI), NN50 count divided by the total number of all NN intervals (pNN50), and the square root of the mean of the sum of the squares of differences between adjacent NN intervals (RMSSD) as time-domain metrics, and use Total Power (TP), very low frequency power (VLF), LF, normalized LF (nLF), HF, normalized HF (nHF) and LF/HF as frequency-domain metrics.

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<td><strong>Study authors</strong></td>
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<td>Versluis, A., et al./2018</td>
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<td>Zimmermann-Schlegel, V., et al./2018</td>
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Note: After mindfulness intervention, improvement in psychological factors such as depression, distress, anger, insomnia, and QoL etc. all proved by scales and questionnaires analyzing.
B. Data Analysis

We search papers on PubMed using keyword mindfulness and heart rate variability, there are 59 papers in recent 10 years, and which were published in English. There were only 18 papers that were the studies focused on the HRV observations during or post mindfulness training. The articles included in this study and their findings are summarized as shown on Table I [13]-[30].

Analyzing the ECG recording, we find that researchers used long-term HRV (24-hour HRV) in 3 studies, and used short term HRV (few minutes) in other 15 papers.

For papers using long-term HRV, participants received MBIs about 4 to 8 weeks. The results showed that pNN50 was significantly increased after mindfulness [26], RMSSD, SDNN, LF and HF were without significantly change [13], [18], and there was association between LF/HF and improved disease symptom [18].

For papers using short-term HRV, participant received MBIs differently from once brief practices to 10 weeks long.

Analyzing the time-domain based HRV results, we find that SDNN and MRSSD were significantly increased after mindfulness [15], [16], [30]. Analyzing the frequency-domain based HRV results, we find that significantly increased HF [15], [17], [20]-[23], [25], [27], [29] with significant decreased LF [18], [19], [21], [25]. The results also showed that increased HF after mindfulness associated with better condition, negatively correlation with stress and disease condition. Conversely, the higher LF correlated with stress condition, negatively correlated with well-being [15], [17].

III. RESULTS

A. The Influence of Mindfulness on HRV

In Table I, we summarized the findings about the influences of mindfulness on HRV from 18 collected papers. The findings showed in Table I are just part of these papers contributions. We omitted those positive effects of mindfulness such as stress reduction, anxiety relieve, mindfulness and life quality improvement etc. proved in papers

From the Table I, we find that RMSSD and SDNN are most useful indices of time-domain, while HF is most useful indices of frequency-domain, though LF and LF/HF also been discussed. After mindfulness intervention, there are significant increase of RMSSD, SDNN and HF values in most of studies and the changes are almost consistent. LF decreased after mindfulness intervention and increased with negative condition are also proved in studies, but the change of LF/HF is uncertain.

For HRV analysis, twenty-four hours ECG recordings were only used in 3 papers; short term ECG recordings had been wildly used in more studies, it is the source of short term HRV.

SDNN is the standard deviation of NN intervals, both Sympathetic Nervous System (SNS) and Parasympathetic Nervous System (PNS) activities can influence SDNN. In short-term HRV, lower values of SDNN can predict high morbidity and mortality, higher values of SDNN is related with better sense of well-being [31], [32].

RMSDD is root mean square of successive RR interval differences, and which is influenced by PNS and correlated with HF [33].

HF (0.15-0.40Hz) value represents the activity of parasympathetic nervous system, it highly correlated with RMSSD. It is reasonable that SDNN, RMSDD and HF have similar results in mindfulness.

In these papers, participants not only include patients but also have healthy individuals, both patient and healthy individuals have similar positive HRV change after mindfulness intervention.

Mindfulness actually can influence on ANS because of improved parasympathetic function. The change of SDNN, RMSDD and HF are similar, and are positive correlated the sense of well-being. SDNN, RMSDD and HF are useful indicators for further study on mindfulness and its action on ANS.

B. Other Findings

Not all research has positive results on HRV analysis of mindfulness, due to complex mechanism of ANS. The possible reasons may be the heterogeneities in subjects (health/patient), training period, and other possible factors.

From the findings of these articles, we found that relative healthy subgroups may gain more positive effects after mindfulness intervention as compared to people with diseases, it can be helpful to explain basic mechanism of mindfulness.

IV. DISCUSSION AND CONCLUSIONS

A. Conclusions

HRV metrics can be useful indices for mindfulness studies. The most useful HRV metrics in previous studies is including SDNN, RMSDD and HF, and all of them are important in ANS function evaluation, especially related parasympathetic nervous system. However, studies with SNS action and the balance of SNS and PNS, remain unsolved.

B. Practical Implications

In this paper, we find that SDNN, RMSDD and HF mostly been used in studies, other metrics of HRV, such as HRVTi, TINN and Poincare analysis etc. can be considered and designed into new studies, it may be helpful to explain the influence on ANS.

In prior studies, we find that different mindfulness skills or training courses may have different effect on ANS. Analyzing these difference can help us to know more about mechanisms of mindfulness and ANS.

Increased SDNN, RMSDD and HF are proved to show better parasympathetic function and we-being. At the same manner, decreased values of SDNN, RMSDD and HF are associated with higher morbidity and mortality risk [32], [34], [35].
REFERENCES


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