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Effects of Tummo Meditation and Niguma Yoga on Brain Activity

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Abstract

Hatha yoga, Qigong, Tai Chi, all ancient practices of the mind, continue to be studied and recognized for their mental and spiritual benefits. However, Tummo meditation and Niguma yoga, ancient practices with origins in the 8th and 11th centuries from the Himalayan Vajrayana tradition, remain obscure and have yet to be disseminated and studied. Previously only practiced by Vajrayana monks during a 3-year retreat, practitioners of Tummo and Niguma often report increased mindfulness and emotional calm following the exercises. In an effort to explore these once secret practices, the Manakai O Mālama Integrative Healthcare Group investigated changes in brain activity prior to and following Tummo combined with Niguma in a seasoned Vajrayana practitioner. Using quantitative electroencephalogram imaging and spectral analysis, an increase in alpha band power and intra-connectivity was observed immediately post-practice, suggesting increased activation of the default mode network (DMN), a brain network directly involved in internalized cognition, self-reflection, emotional regulation, and creativity. These findings not only offer a scientific basis for further research, but also provide neurological evidence for the mental and cognitive benefits of Tummo meditation and Niguma yoga. With continued study, it is possible to validate ancient practices of Tummo and Niguma as effective health interventions. Moreover, this study furthers research showing how yoga and meditation techniques may be of benefit for behavioral health. In particular, cultural healing components of yoga and meditation may be more easily deployed in minority populations like Native Hawaiians, who are disproportionately at risk for mental health issues in Hawai'i.

Abbreviations & Acronyms

DMN = default mode network
EEG = electroencephalogram
FFT = fast fourier transform
Hz = hertz
PLI = phase lag index
PSD = power spectrum density

Introduction

Ancient meditation and yoga practices have long been reported to impart benefits to mental and physiological health. Recent studies demonstrate quantifiably beneficial effects of meditation and yoga, including significant changes in brain power, connectivity, and structure in the hippocampus, amygdala, prefrontal cortex, and cingulate cortex, which are associated with enhancements in mood, mindset, and cognition.[1,2] Yoga meditators were also shown to have greater gray matter volume, slower decline of gray matter with age, and fewer cognitive failures in comparison to matched controls, suggesting that yoga meditation promotes neuroplasticity and may be neuroprotective against age-related decline.[3,4] As Native Hawaiians suffering from mental health disorders have been shown to prefer cultural ways of healing, yoga and meditation offer a unique therapeutic advantage to the population.

Tummo meditation and Niguma yoga, the latter once a closely-guarded practice, were only recently made available to the public in 2022. Tummo involves repetitively holding the breath during isometric contraction of abdominal muscles, resulting in increased sympathetic nervous system tone, thermogenesis, and altered brain states.[5-7] Niguma is a set of 25 Tibetan yoga exercises, comprising a broad range of difficulty, however given its only recent public practice, no scientific studies have been conducted on Niguma to date. When Tummo and Niguma are performed concurrently, Niguma magnifies the benefits of Tummo's isometric muscle engagement through rhythmic reinforcement while stabilizing the body during Niguma movements. Post-practice, practitioners report increased stress resilience, focus, and a dynamic mental state that perpetuates a deeper perspective of reality. Measurement of the activation of brain networks involved in these described experiences may provide more insight into the origins of reported phenomena.

Previous studies on meditation and yoga have focused on brain regions that form a network which is active during internalized modes of cognition, self-reflection, emotional regulation, and creativity, known as the default mode network (DMN).[8] The DMN has not yet been investigated in Tummo combined with Niguma. Resting-state brainwave activity present during awake eyes-closed and relaxed states as measured via an electroencephalogram (EEG) is an accepted proxy for DMN activation, with overlapping hubs of generation within the medial prefrontal cortex and inferior parietal cortices.[9] This rhythm is alpha activity, a cortical oscillatory rhythm with a frequency between 8-13 Hz, which varies between people, but is a stable physiological trait within an individual.[10] Higher amounts of resting state alpha activity are associated with greater DMN intra-network activation.[9,11] Importantly, DMN intra-connectivity is lower between frontal and posterior regions, and activation is less stable in people with mental health disorders.[12,13]

Standard EEG spectral analysis and connectivity measures, coherence and phase lag index (PLI), may be used to track EEG changes over time and indicate network activation and connectivity.[14-16] These measures compare variance of an EEG signal between 2 locations over time and reflect network connectivity, with PLI being more immune to effects of volume conduction. Both measures are scaled from 0-1, with a measurement of 0 reflecting no connectivity and 1 reflecting perfect connectivity. Increases in alpha power were reported following Kundalini yoga, Qigong, Transcendental and Tummo meditation; however, no studies examined DMN-specific alpha intra-connectivity.[5-7,17] Alpha connectivity and amplitude indicate the strength of communication between brain regions for this band, with alpha hypoconnectivity linked to functional brain dysconnectivity in Alzheimer's disease and mild cognitive impairment,[18] alpha connectivity decreasing following sleep deprivation,[19] and alpha amplitude decreasing following traumatic brain injuries.[20] These measures have been previously reported to increase in meditation studies, however none report on the combination of Tummo and Niguma.[21, 22] The present case study investigates the effect of Tummo and Niguma on resting state cortical function within DMN hubs as measured via awake eyes-closed and relaxed state EEG in a seasoned practitioner of this meditation and yoga practice.

Methods

The subject was a 32-year-old Vajrayana teacher trained in Tummo and Niguma with more than 15 years' experience of this meditation and yoga practice. The subject presented with no neurological or psychiatric disorders, brain injury, or addictions. The subject was recruited through Manakai O Mālama Integrative Healthcare Group and consented to 2 ten-minute EEGs recorded before and after a Tummo and Niguma session in a quiet room with the practitioner's personal cushion mat. The subject was in an awake, eyes-closed and relaxed state during EEG recordings. The session lasted approximately 35 minutes.

To measure changes in alpha activity, representative of DMN activation, a Deymed Truscan EEG amplifier was used with a 19-lead EEG cap using a standard 10-20 EEG setup, recorded at <10k Ohm impedance. Preprocessing of EEG was performed with the python module Autoreject 0.4.2,[23] and only post-processed artifact-free EEG epochs were utilized in analysis.

A fast fourier transform (FFT) routine was run for spectral analysis from which EEG frequency band power percentage was calculated for 4 main types of brainwaves: delta, theta, alpha, and beta. Connectivity measures were performed to review DMN intra-connectivity pre- and post-session in the bilateral parietal lobules, corresponding to P3 and P4 electrode locations, and the medial prefrontal cortex, corresponding to the Fz electrode location. Coherence and PLI were calculated for P3-Fz and P4-Fz electrode pairs.[24] A power spectrum density (PSD) figure was generated with regions of interest plotted. PSD calculated regions of interest were frontal (F3, F4, Fz), central (C3, C4, Cz) and posterior (Pz, P3, P4, O1, O2). These measures were repeated for pre-and post-session EEGs.

Results

Following the Tummo and Niguma session, the subject reported a change in emotional state to one with cognitive clarity, calmness, and a state without emotions of "grasping, desire, or jealousy." Pre- and post-session FFT data are shown in **Table 1**. All anterior to posterior alpha connectivity measures, which are generally lower in persons with mental health disorders, markedly increased following the practice session. Alpha band percent power increased by a proportionally large margin, (31.6% to 56.4%), following the session. As alpha band activity increased proportionally more than other band activity, the percent power of delta, theta, and beta bands decreased. For Coherence and PLI measures, all alpha connectivity measures increased relative to pre-session, the most in the right hemisphere (ie, P4-Fz).

Pre- and post-FFT power spectrum density (PSD) plots are displayed in **Figure 1** with pre-session PSD presented in pink and post-session PSD presented in blue. Theta (4-8Hz) and alpha (8-13Hz) wide-band activity increased in frontal, central, and posterior regions. The increase in alpha band activity was higher than that observed for theta band activity. As reported in observations of the peak of alpha activity following meditation,[17] the subject's alpha peak frequency was slower following the Tummo and Niguma session, decreasing from approximately 10.8Hz to 9.5Hz. Meanwhile, peak theta frequency increased from approximately 6.2Hz to 6.5Hz. Minimal changes were noted in beta band (13-30Hz) PSD amplitude.

Discussion

Tummo meditation and Niguma yoga are ancient practices that have potential for improving the quality of life for any who practice. This case study explored the impact of combined Tummo and Niguma on brain activity. Following Tummo and Niguma, a 24.8% increase in alpha band power and up to 0.13 increase in alpha connectivity measures were observed. Decreases were observed in percent band power for delta, theta, and beta activity, corresponding to the large increase in alpha percent power reported. Higher amounts of alpha activity are associated with greater DMN intra-network activation, a network active in intrinsic awareness, emotional control, and creative processes. As the DMN is abnormally activated and connected in mental health disorders,[12,13] the observed increase in alpha intra-connectivity and activation suggests beneficial changes in brain activity following combined Tummo and Niguma practice. Previous studies of Tummo reported similar increases in alpha band activity and coherence in seasoned practitioners, up to 36% increase in alpha amplitude during meditation with significant increases in alpha coherences[5-7]; however there are no reports of Niguma yoga utilizing EEG measures. Notably, the present study did not directly analyze DMN activity via fMRI or a measure of

Table 1. Pre- and Post-Session Fast Fourier Transformed (FFT) Frequency Band Percentage, Alpha Coherence, and Alpha Phase Lag Index in a Participant Practicing Tummo Meditation and Niguma Yoga

	Frequency Band Percentage (%)				Alpha Coherence		Alpha Phase Lag Index	
	Delta	Theta	Alpha	Beta	P3-Fz	P4-Fz	P3-Fz	P4-Fz
Pre-Session	27.1	29.8	31.6	11.5	0.63	0.65	0.24	0.23
Post-Session	14.2	21.7	56.4	7.6	0.67	0.70	0.32	0.36

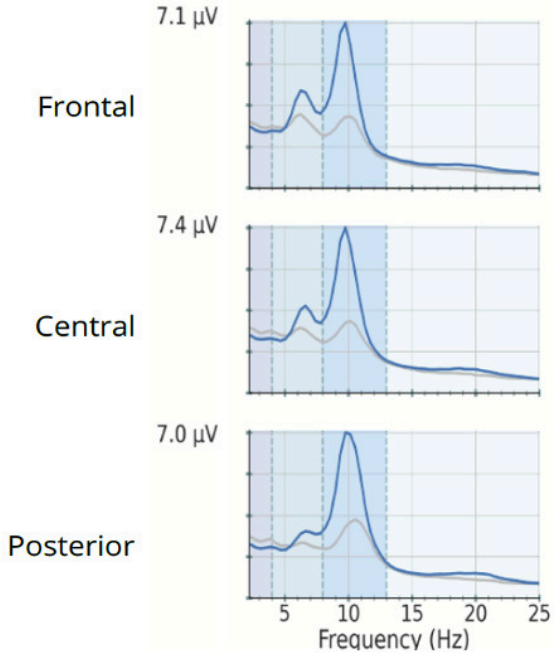

Figure 1. Pre-Session (pink) and Post-Session (blue) Fast Fourier Transformed (FFT) Power Spectrum Density Plotted by Band Frequency and Power in a Participant Practicing Tummo Meditation and Niguma Yoga

functional connectivity, however previous studies have highlighted increases in DMN functional connectivity in meditation.[8]

Limitations in this report include analysis on a single subject and lack of a comparison group, in-depth statistical analysis, or follow-up EEGs to quantify the durability of the effects of Tummo and Niguma practice. Additional research with more practitioners, a novice group, and more extensive neuroimaging to further characterize the significance of observed neurological differences is necessary to understand the impact of Tummo and Niguma on brain function.

Regardless, the demonstration of changes in brain activity is an important step in furthering the understanding of Tummo meditation and Niguma yoga's impact on mental health.

Native Hawaiians are at higher risk for mental health issues and show lower rates of seeking mental health care due to colonization risk-factors and cultural stigmatization.[25] Validating and incorporating ancient mind practices into health care may help bridge cultural barriers as Native Hawaiians and other marginalized groups may value tradition and spirituality over Western medical beliefs. Additionally, Tummo and Niguma are noninvasive, non-pharmacological, and low-cost to implement. Therefore, they hold potential in offering additional mental healthcare modalities for these groups.

Disclosure

None of the authors identify any conflict of interest.

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