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OPINION
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Sleep Disorder in Drug Addiction: Treatment With Transcranial Magnetic Stimulation

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INTRODUCTION

Drug addiction subjects sleep less and worse, when compared to healthy control population (1). Importantly, drug addiction are 5–10 times more likely to exhibit sleep disorders than others (2). Drugs of abuse directly modify the sleep quality on both current abusers and abstinent dependents; most drugs prolong the sleep onset latency, reduce the sleep efficiency and total sleep time (3, 4). Sleep disorder is prevalent in drug dependents, ranging from opioid, methamphetamine, cannabis, to alcohol abuse patients (5, 6). Addicts usually have common diseases, including depression, bipolar disorder, schizophrenia, and most of these patients have sleep disorders (7, 8). People with sleep disorders tend to self-treat with alcohol and sedatives, which in turn may promote drug abuse and increase the risk of recurrence (9). Sleep disruption is associated with negative mood status, anxiety and often relate to additional drug intake. Targeting sleep disorder in drug dependents could be important in management of clinical symptom severity and prevention of relapse (10).

TRANSCRANIAL MAGNETIC STIMULATION (TMS)

Transcranial magnetic stimulation (TMS) is a way to non-invasively stimulate the brain (11). By positioning a coil over the skull, the electrical current passing through the coil could induce alternating magnetic field, which then transform to alternating current in the cortex and the activation of local neural network. The effects of cortical activation could transmit to connected brain regions, and modulate the release of many different neurotransmitters (12).

Repetitive TMS (rTMS) has been approved for treatment of major depression disorder since 2008, and rTMS has also been employed in management of different psychiatric disorders (13–15). For instance, rTMS could alleviate hallucination in psychotic patients, reduce chronic pain and anxiety, and treat obsessive compulsive disorder (OCD) (16, 17). Recently, rTMS is shown to be effective in addictive disorders as well. High frequency rTMS treatment reduces craving for drugs and intake for cocaine, heroin, methamphetamine, and cannabis (18–23).

On the other hand, rTMS has been used for sleep modulation recently, given the fact that TMS pulse induces slow-wave like activity in the brain (24), and rTMS treatment could re-balance the disrupted network in sleep disorders (25–28).

rTMS FOR SLEEP DISORDER IN ADDICTION

Evidence that rTMS is significantly effective in treating primary insomnia, depression with insomnia and general anxiety with insomnia suggests rTMS intervention is likely to be a promising approach in the treatment of sleep disorder (29–31).

Ensuring the sleep improvement during addiction treatment is important as quality control of detoxification, and prevention for relapse (10, 32). Normalized sleep pattern and circadian rhythm could increase the resilience to addiction (33). Treatment with Benzodiazepines resulted in controversies and with risks for new addiction formation (34). These argues for the need of physical rehabilitation approaches in improving sleep quality for drug dependents.

Emerging studies demonstrated that the potential of rTMS treatment in improving sleep quality and addiction symptoms. One recent study focused on methamphetamine at early abstinence and performed 10 days of high-frequency (10 Hz) rTMS treatment (totally 20,000 pulses) (35). The results showed that rTMS treatment rather than sham treatment reduced withdrawal symptoms, alleviate depression and anxiety state, and improve sleep quality efficiently, with lasting effects in follow-up measurements. Notably, the changes in craving score correlated linearly to sleep improvement. It is possible that shared neurochemistry changes (e.g. increased dopamine concentration in striatum) underlie these behavioral improvements.

Another study recruited male subjects with methamphetamine abuse history, but at extended period of abstinence (e.g. after 3 months) (36). The subjects reported certain levels of depression, anxiety, and sleep disruption. The authors employed chronic rTMS protocol for 6 weeks, with a total of 180,000 pulses for each subject. Following the treatment, the mood status change correlated to the changes in sleep improvement. These results co-suggest for the potential of rTMS in sleep disorder of addicted subjects.

OPINION

Taken together, sleep disorder as a prevalent symptom in addiction could be treated with rTMS procedures. Few questions remain to be elucidated: (1) Can rTMS procedure be combined with sleep enhancing drugs, such as Benzodiazepines? (2) What is the most important neurochemical component underlying the effects of rTMS on sleep improvement? (3) What is the optimal protocol for rTMS procedure for sleep disorder and addiction treatment? Future studies are required to validate and expand the use of rTMS for sleep disorders in different drug addiction.

AUTHOR CONTRIBUTIONS

XD, WX and XL contributed equally to this work. XD, WX drafted the manuscript. XL revised the manuscript. DZ and CH provided funds. All authors reviewed content and approved the final manuscript for publication.

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REFERENCES

1. Jinsong T, Yanhui L, Haoyu H, Qijian D, Guanbai Z, Chang Q. Sleeping problems in Chinese illicit drug dependent subjects. *BMC Psychiatry* (2015) 15:28. doi: 10.1186/s12888-015-0409-x
2. Yanhui L, Jinsong T, Tieqiao L, Xiaogang C, Tao L, Wei H. Sleeping problems among Chinese heroin-dependent individuals. *Am J Drug Alcohol Abuse* (2011) 37:179–83. doi: 10.3109/00952990.2010.535580
3. Herrmann ES, Johnson PS, Bruner NR, Vandrey R, Johnson, MW. Morning administration of oral methamphetamine dose-dependently disrupts nighttime sleep in recreational stimulant users. *Drug Alcohol Depend* (2017) 178:291–5. doi: 10.1016/j.drugalcdep.2017.05.013
4. Gordon HW. Differential effects of addictive drugs on sleep and sleep stages. *J Addict Res (OPAST Group)* (2019) 3:2. doi:10.33140/JAR.03.02.01
5. Irwin MR, Bjurstrom MF. and R Olmstead. Polysomnographic measures of sleep in cocaine dependence and alcohol dependence: implications for age-related loss of slow wave, stage 3 sleep. *Addiction* (2016) 111:1084–92. doi: 10.1111/add.13300
6. Hodges, SE, Pittman, B. and Morgan, PT. Sleep perception and misperception in chronic cocaine users during abstinence. *Sleep* (2017) 40:3. doi:10.1093/sleep/zsw069
7. Kyung Lee, E. and Douglass, AB. Sleep in psychiatric disorders: where are we now? *Can J Psychiatry* (2010) 55:403–12. doi: 10.1177/070674371005500703
8. Putnins, SI, Griffin ML, Fitzmaurice GM, Dodd DR, Weiss RD. Poor sleep at baseline predicts worse mood outcomes in patients with co-occurring bipolar disorder and substance dependence. *J Clin Psychiatry* (2012) 73:703–8. doi: 10.4088/JCP.11m07007
9. Mahfoud Y, Talih F, Streem D. and K Budur Sleep disorders in substance abusers: how common are they? *Psychiatry-Interpers Biol Processes* (2009) 6:38–42.
10. Miller MB, DiBello AM, Lust SA, Carey MP, KB Carey. Adequate sleep moderates the prospective association between alcohol use and consequences. *Addict Behav* (2016) 63:23–8. doi: 10.1016/j.addbeh.2016.05.005
11. Barker AT, Jalinous R, Freeston IL. Non-invasive magnetic stimulation of human motor cortex.*Lancet* (1985) 325:1106–7. doi: 10.1016/S0140-6736(85)92413-4
12. Hallett M. Transcranial magnetic stimulation and the human brain.*Nature* (2000) 406:147–50. doi: 10.1038/35018000
13. Bajbouj M, Brakemeier EL, Schubert F, Lang UE, Neu P, Schindowski C. Repetitive transcranial magnetic stimulation of the dorsolateral prefrontal cortex and cortical excitability in patients with major depressive disorder. *Exp Neuro l* (2005) 196:332–8. doi: 10.1016/j.expneurol.2005.08.008
14. Fitzgerald PB, Benitez J, de Castella A, Daskalakis ZJ, Brown TL, Kulkarni J. A randomized, controlled trial of sequential bilateral repetitive transcranial magnetic stimulation for treatment-resistant depression. *Am J Psychiatry* (2006) 163:88–94. doi: 10.1176/appi.ajp.163.1.88
15. O'Reardon JP, Solvason HB, Janicak PG, Sampson S, Isenberg KE, Nahas Z. Reply regarding "efficacy and safety of transcranial magnetic stimulation in the acute treatment of major depression: a multisite randomized controlled trial". *Biol Psychiatry* (2010) 67:e15–7. doi: 10.1016/j.biopsych.2009.06.027

16. Lefaucheur JP. The use of repetitive transcranial magnetic stimulation rTMS) in chronic neuropathic pain. *Neurophysiol Clin = Clin Neurophysiol* (2006) 36:117–24. doi: 10.1016/j.neucli.2006.08.002
17. Leo RJ, Latif T. Repetitive transcranial magnetic stimulation (rTMS) in experimentally induced and chronic neuropathic pain: a review. *J Pain Off J Am Pain Soc* (2007) 8:453–9. doi: 10.1016/j.jpain.2007.01.009
18. Shen Y, Cao X, Tan T, Shan C, Wang Y, Pan J, et al. 10-Hz Repetitive transcranial magnetic stimulation of the left dorsolateral prefrontal cortex reduces heroin cue craving in long-term addicts. *Biol Psychiatry* (2016) 80:3. e13–4. doi: 10.1016/j.biopsych.2016.02.006
19. Terraneo A, Leggio L, Saladini M, Ermani M, Bonci A, Gallimberti L. Transcranial magnetic stimulation of dorsolateral prefrontal cortex reduces cocaine use: A pilot study. *Eur Neuropsychopharmacol* (2016) 26:37–44. doi: 10.1016/j.euroneuro.2015.11.011
20. Liu Q, Shen Y, Cao X, Li Y, Chen Y, Yang W, et al. Either at left or right, both high and low frequency rTMS of dorsolateral prefrontal cortex decreases cue induced craving for methamphetamine. *Am J Addict* (2017) 26(8):776–9. doi: 10.1111/ajad.12638
21. Bolloni C, Badas P, Corona G, Diana M. Transcranial magnetic stimulation for the treatment of cocaine addiction: evidence to date. *Subst Abuse Rehabil* (2018) 9:11–21. doi: 10.2147/SAR.S161206
22. Pettorruso M, Martinotti G, Santacroce R, Montemitro C, Fanella F, di Giannantonio M. rTMS Reduces psychopathological burden and cocaine consumption in treatment-seeking subjects with cocaine use disorder: an open label, feasibility study. *Front Psychiatry* (2019) 10:621. doi: 10.3389/fpsyt.2019.00621
23. Ekhtiari H, Tavakoli H, Addolorato G, Baeken C, Bonci A, Campanella S. Transcranial electrical and magnetic stimulation (tES and TMS) for addiction medicine: a consensus paper on the present state of the science and the road ahead. *Neurosci Biobehav Rev* (2019) 104:118–40. doi:10. 1016/j.neubiorev.2019.06.007
24. Marcello M, Fabio F, Esser SK, Riedner BA, Reto H, Michael M. Triggering sleep slow waves by transcranial magnetic stimulation. *Proc Natl Acad Sci U S A* (2007) 104:8496–501. doi: 10.1073/pnas.0702495104
25. César Augusto MS, Jean-Christian B, Simon G, Frédéric S. Acute upper airway muscle and inspiratory flow responses to transcranial magnetic stimulation during sleep in apnoeic patients. *Exp Physiol* (2013) 98:946–56. doi: 10.1113/expphysiol.2012.070359
26. Mensen A, Gorban C, Niklaus M, Kuske E, Khatami R.The effects of theta-burst stimulation on sleep and vigilance in humans. *Front In Hum Neurosci* (2014) 8:420. doi: 10.3389/fnhum.2014.00420
27. Sánchez-Escandón O, Arana-Lechuga Y, Terán-Pérez G, Ruiz-Chow A, González-Robles R, Shkurovich-Bialik P. Effect of low-frequency repetitive transcranial magnetic stimulation on sleep pattern and quality of life in patients with focal epilepsy.*Sleep Med* (2016) 20:37–40. doi: 10.1016/j.sleep.2015.11.022
28. Lanza G, Cantone M, Aricò D, Lanuzza B, Cosentino F, Paci D, et al. Clinical and electrophysiological impact of repetitive low-frequency transcranial magnetic stimulation on the sensory-motor network in patients with restless legs syndrome. *Ther Adv In Neurol Disord* (2018) 11:1–12. doi: 10.1177/1756286418759973
29. Park EJ, Lee SJ, Koh DY, Han YM. Repetitive transcranial magnetic stimulation to treat depression and insomnia with chronic low back pain. *Korean J Pain* (2014) 27:285–9. doi: 10.3344/kjp.2014.27.3.285
30. Huang Z, Li Y, Bianchi MT, Zhan S, Jiang F, Li N. Repetitive transcranial magnetic stimulation of the right parietal cortex for comorbid generalized anxiety disorder and insomnia: A randomized, double-blind, sham-controlled pilot study. *Brain Stimul* (2018) 11:1103–9. doi: 10.1016/j.brs.2018.05.016
31. Song P, Lin H, Li S, Wang L, Liu J, Li N. Repetitive transcranial magnetic stimulation (rTMS) modulates time-varying electroencephalography (EEG) network in primary insomnia patients: a TMS-EEG study. *Sleep Med* (2019) 56:157–63. doi: 10.1016/j.sleep.2019.01.007
32. Neu P, Sofin Y, Danker-Hopfe H. The effect of detoxification on sleep: how does sleep quality change during qualified detoxification treatment? *J Addict* (2018) 2018:9492453. doi: 10.1155/2018/9492453
33. Logan RW, Hasler BP, Forbes EE, Franzen PL, Torregrossa MM, Huang YH. Impact of sleep and circadian rhythms on addiction vulnerability in adolescents. *Biol Psychiatry* (2018) 83:987–96. doi:10.1016/j.biopsych.2017.11.035
34. Dupont RL. "Should patients with substance use disorders be prescribed benzodiazepines?" No. *J Addict Med* (2017) 11:84–6. doi: 10.1097/ADM.0000000000000291
35. Liang Y, Wang L, Yuan T-F. Targeting withdrawal symptoms in men addicted to methamphetamine with transcranial magnetic stimulation: a randomized clinical trial. *JAMA Psychiatry* (2018) 75:1199–201. doi: 10.1001/jamapsychiatry.2018.2383
36. Lin J, Liu X, Li H, Yu L, Shen M, Lou Y. Chronic repetitive transcranial magnetic stimulation (rTMS) on sleeping quality and mood status in drug dependent male inpatients during abstinence. *Sleep Med* (2019) 58:7–12. doi: 10.1016/j.sleep.2019.01.052

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