Slow oscillating transcranial direct current stimulation during sleep has a sleep-stabilizing effect in chronic insomnia: a pilot study

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SUMMARY
Recent evidence suggests that lack of slow-wave activity may play a fundamental role in the pathogenesis of insomnia. Pharmacological approaches and brain stimulation techniques have recently offered solutions for increasing slow-wave activity during sleep. We used slow (0.75 Hz) oscillatory transcranial direct current stimulation during stage 2 of non-rapid eye movement sleeping insomnia patients for resonating their brain waves to the frequency of sleep slow-wave. Six patients diagnosed with either sleep maintenance or non-restorative sleep insomnia entered the study. After 1 night of adaptation and 1 night of baseline polysomnography, patients randomly received sham or real stimulation on the third and fourth night of the experiment. Our preliminary results show that after termination of stimulations (sham or real), slow oscillatory transcranial direct current stimulation increased the duration of stage 3 of non-rapid eye movement sleep by 33 ± 26 min (P = 0.026), and decreased stage 1 of non-rapid eye movement sleep duration by 22 ± 17.7 min (P = 0.028), compared with sham. Slow oscillatory transcranial direct current stimulation decreased stage 1 of non-rapid eye movement sleep and wake time after sleep-onset durations, together, by 55.4 ± 51 min (P = 0.045). Slow oscillatory transcranial direct current stimulation also increased sleep efficiency by 9 ± 7% (P = 0.026), and probability of transition from stage 2 to stage 3 of non-rapid eye movement sleep by 20 ± 17.8% (P = 0.04). Meanwhile, slow oscillatory transcranial direct current stimulation decreased transitions from stage 2 of non-rapid eye movement sleep to wake by 12 ± 6.7% (P = 0.007). Our preliminary results suggest a sleep-stabilizing role for the intervention, which may mimic the effect of sleep slow-wave-enhancing drugs.

INTRODUCTION
Primary insomnia (PI) is defined as a non-restorative sleep accompanied by problems in initiating or maintaining of sleep, in the absence of clinically significant medical, neurological or psychiatric disorder. Having PI for more than 3 months is referred to as chronic insomnia, a persistent condition that in the long-term decreases the quality of life, and increases the risk of morbidity and mortality due to physical and mental illnesses (Dew et al., 2003).

Global and growing epidemics of insufficient sleep, insulin resistance and obesity are suggested to be mechanistically correlated (Lucassen et al., 2012). It is estimated that in the

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