

Hypothesis

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Hypothesis

Do Face Masks Inhibit Yawning? An Important Consideration in Sleep Studies

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Abstract: The COVID-19 pandemic has led to the widespread use of face masks to reduce disease transmission, but one unintended consequence is that this may negatively impact sleep and arousal by altering the expression of yawning. Yawns are defined by an involuntary and powerful gaping of the jaw with inspiration, and the typical design of face masks may restrict and/or disrupt the mandibular jaw movement and counter-current heat exchange during this behavior. Face masks additionally impair the contagious nature of yawning by disrupting the recognition of yawning in others within social/community settings. Given that the neurophysiological consequences of yawning function in facilitating changes in state and arousal, and most notably transitions in waking and sleeping via thermoregulation, face mask usage could be an important variable to consider within sleep studies. We briefly outline these connections, highlight some important factors to consider, and discuss the implications for both prior and current research on sleep.

Keywords: face mask; sleep studies; yawning

Highlights

- Sleep and fatigue are closely associated with yawning.
- Face mask-wearing could impair the initiation, intensity, duration, and physiology of normal yawning and thus might interfere with sleep physiology and epidemiology.
- Face mask-induced effects may confound the results of sleep-related epidemiologic studies in many ways.

Introduction

Sleeping and waking transitions and hypersomnolence are strongly associated with yawning [1,2]. Yawning is a physiological behavior that takes the form of a complex reflex. A yawn is a paroxysmic cycle characterized by a standard cascade of movements over roughly 6 seconds in duration [3]. Yawns are highly stereotyped, including an involuntary and powerful gaping of the jaw with deep inspiration, followed by a peak muscular contraction and a passive closure of the jaw with expiration. Phylogenetically old, comparative research shows that yawning functions in facilitating changes in state, modifying arousal, and promoting brain thermoregulation through intracranial circulation and counter-current heat exchange [4]. Yawning is also socially contagious in humans and some non-human animals, which appears to function in the synchronization of group activity and vigilance states [5,6].

Consistent with the functional significance of yawning, current evidence suggests that drowsiness, as a marker of a down regulation in arousal and vigilance, can be regarded as the most common trigger of yawning. Subjective ratings of sleepiness predict yawning [7], the frequency of yawning is tightly coupled with sleeping and waking transitions, and excessive yawning may indicate sleep deprivation [8]. Boredom, which is also a trigger for yawning [9], occurs when the main source of stimulation in an individual's environment can no longer sustain their attention or interest. This too induces drowsiness by stimulating the sleep generating system [10]. Furthermore, recent studies have shown that the tendency to yawn contagiously is also positively associated with subjective ratings of sleepiness [11].

Both phylogenetically and ontogenetically, there is also a potential link between yawning and REM sleep [12–15]. A parallel curve has been demonstrated the similitude of the evolution of yawn frequency and the amount of REM sleep [16–18]. Furthermore, the yawning rhythm changes brain wave activity in predicted ways, as measured by EEG [19,20]. For instance, yawning changes sleep EEG slow-wave activity [20]. In one study, people complaining of excessive sleepiness were spontaneously yawning while trying to stay awake in a darkened and quiet room [19]. Yawning bouts were preceded and followed by a greater delta activity in EEG than movements, while after yawning alpha rhythms were significantly attenuated, decelerated, and shifted towards the central brain region [19].

Aside from various and consistent links between yawning and sleep propensity, sleep problems, and sleep stages, the physiology of yawning intersects with thermoregulatory function [21], and atypical or frequent patterns of yawning have been associated with conditions such as epilepsy, multiple sclerosis, stroke, and systemic lupus erythematosus [22,23]. From the standpoint of neuropharmacology, a wide range of neurotransmitters and neurohormones are involved in the induction and regulation of yawning, including dopamine, acetylcholine, serotonin, glutamate, opioids, oxytocin, GABA, nitric oxide, adrenergics, as well as the proopiomelanocortin -derived peptides ACTH and α -MSH. Interestingly, despite this diverse set of neurotransmitters, the major part of the yawning process is mediated by at least three distinct pathways, all of which appear to converge on cholinergic neurons within the hippocampus [24]. Notably, the pattern of yawning is distinguishably different in physiologic and pathologic conditions [13]. For further examination of these and other intersections, we refer the interested reader to recent review articles covering these topics [22,24–27].

Hypothesis: *By disrupting normal yawning, face masks may impact the results of sleep studies.*

The typical and everyday expression of yawning appears to regulate important daily activities and mental states, namely those involved in transitions in arousal and state change linked with sleeping and waking. Here, we propose that face mask-wearing during COVID-19 may inhibit and/or modify this adaptive response in important ways, thus making it an important factor in sleep studies carried out during or after the COVID-19 pandemic. Most masks used for reducing the transmission of COVID-19 are designed with a fabric that is in immediate proximity to the mouth, and thus are known to impair mouth movement [28]. As a result, normal patterns of yawning could be modulated by restricting mandibular jaw movement. That is, wearing a tightly fitted mask may inhibit the trigger of yawns altogether, as well diminish their intensity and/or duration upon initiation. Given that face masks also impact air flow, they could further impair counter-current heat exchange with the ambient air, which is a main functional component to yawning [29]. Thus, widespread face masks use thereby could alter critical functional patterns of spontaneous yawning in an individual setting by reducing the incidence and/or magnitude of this behavior, which could subsequently alter sleep onset, sleep duration, and fatigue.

Furthermore, face masks additionally impair contagious yawning through the inhibition of yawn detection [30]. Given that typical patterns of spontaneous yawning appear to facilitate normal sleeping and waking cycles [9,31], and contagious yawning can modify vigilance and synchronize sleep transitions within groups [32], face mask-wearing could have important social impacts on sleep onset and fatigue as well. Taken together, we argue that the use of masks could create clinical uncertainty and be an important factor to consider in epidemiological studies of sleep.

Evaluation of Hypothesis

Important Factors to Consider in Relation to Face Masks and Yawning

Since there are some important similarities and differences in terms of face mask-wearing, yawning, and sleep quality in different populations and settings, we present some important factors to consider during the COVID-19 pandemic that could alter the results of sleep studies. In this brief overview, additional factors created by the COVID-19 pandemic itself, will not be covered.

(i.) Gender and affiliation: Recent studies report that women have a more responsible attitude toward COVID-19 than men [33,34]. Most studies suggest that men are more inconsiderate towards face mask-wearing, though this is not always the case [35]. Collectively, a cavalier attitude among men regarding mask-wearing may negatively affect their COVID-19 risk profile [36]. While the rate of spontaneous yawning does not vary between men and women [37], and most evidence on contagious yawning in humans demonstrates that there is no difference between women and men [38], one study indicated that women were most susceptible of yawn contagion [39]. If true, women could be more affected by using face masks. Relatedly, a study investigating gender differences in the association between smartphone use and sleep quality found that the inverse correlation between smartphone use and sleep quality was mainly driven by women [25].

Observational studies have indicated that social bonding and affiliation predicts the occurrence of yawn contagion, i.e., contagious yawning is reported to be highest between friends and family members [40]. While this finding could be driven by differences in social attention, i.e., people may be more likely to notice the yawns of those they are about [41], the use of face masks is expected to alter the rate of yawn contagion more so in social settings where people are closely affiliated.

(ii.) Age: The sociodemographic profile of mask-use during the COVID-19 outbreak is different among young and older adults [42–44]. For example, people 55 years and older reportedly had higher odds of wearing masks most or all the time [45], suggesting higher compliance with recommended preventive behaviors among the elderly compared to younger people [46].

In this case, older adults also tend to yawn less than younger folks [7], mainly in the morning and mid-afternoon. Like young people, older subjects yawn mostly after awakening and before sleep but manifest an earlier morning peak and evening rise [7]. A similar negative correlation between yawn contagion and age also been documented [47,48]. Thus, these age-related differences in behavior (in terms of face mask-wearing behavior and yawning frequency/timing) suggest that, among those that regularly use masks, youngest people may be most influenced by their potential negative impact.

(iii.) Occupation settings: While only 2.3% of the Chinese workforce reports insomnia [49], 58% of the frontline medical staff reports suffering from severe insomnia [50]. Similar variability has also been observed in other countries. In Italy, for example, the prevalence of insomnia ranged from 37.6% to 57% [51].

During the pandemic, many night workers were required to wear a face mask. Yawning is disproportionately more frequent in the early morning and the late evening, i.e., close to sleeping and waking transitions. Consistent with the view that yawns represent a behavioral sign of sleep propensity, the temporal distribution of yawning frequency also varies between chronotypes [2]. Similarly, interindividual variation in contagious yawning is thought to depend on multiple factors, such as an individual's propensity to spontaneously yawn and a heightened level of sleepiness [32]. As a result, the contagious effect of yawning also varies across the day. Both spontaneous and contagious yawning peak in the early morning and the late evening, according to the sleepiness time course [7]. Thus, disruptions in yawning resulting from face mask use would be expected to disproportionately influence individuals working in certain professions, potentially interacting with differences in sleep-wake rhythms. Consistent with this view, night shift workers, including health care professionals, are concomitantly at a higher risk of COVID-19 and sleep disorders [52–56].

Discussion

In summary, we put forth the argument that masks may alter the results of sleep-related clinical/epidemiologic studies in important many ways, namely through impairment or modification of yawning as well as the recognition of yawns in others. These potential effects, which are expected to vary across individuals and settings, should be separately considered when analyzing data to segregate genuine sleep disturbances from those that are confounded by wearing a face mask. Given that policies regarding COVID-19 prevention/mitigation have varied considerably at the international level [57], the impact of face masks on prior sleep studies would need to be evaluated

based on the sample collected. Similarly, the practice and technique of face mask use has also varied across different community settings [58–61].

The potential impacts of face mask use on yawning, and ultimately sleep, are likely to be linked to variables such as duration of wearing and frequency of changing, as well as the thickness, type, sealing, and tightness of the face mask [62,63]. We briefly discussed the possible implications here, but further research in these areas is needed. In addition to affecting thermoregulation and arousal/vigilance by potentially disrupting the typical expression and yawning, other mechanisms that may subtly alter sleep studies include the incidence of dyspnea, hypercapnia/hypoxia, and/or headache following prolonged face mask use [62]. In addition, it is already known that in systemic conditions such as Sjögren syndrome, face mask-induced dry eye could be combined with pre-existing eye dryness and exacerbate sleep disorders [64].

Conclusion

Face mask usage should be considered within systematic reviews and meta-analyses (pre-COVID-19 vs. post-COVID-19) as well as within existing and future studies on sleep. If it proves to be the case that face masks do significantly impact sleep propensity, duration, and/or quality by altering yawning, this will have important implications for sleep-related research.

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Abbreviations

ACTH, adrenocorticotrophic hormone; α -MSH, alpha-melanocyte-stimulating hormone; COVID-19, coronavirus disease 2019; EEG, electroencephalogram; GABA, gamma-aminobutyric acid; REM, rapid eye movement.

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