Sleep in the Athlete

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KEYWORDS

- Sleep • Athlete • Mental health • Performance • Jet lag • Insomnia

KEY POINTS

- Sleep disorders are prevalent in both the general population and athletes, but there are unique factors that athletes face due to the high-stress competitive environment.
- Sleep is crucial for general health, cognitive function, lowering injury risk, and maintaining athletic performance.
- Taking a sleep history, evaluating sleep objectively, and addressing other related factors such as mental health and substance abuse are essential in diagnosing and understanding sleep disorders.
- Treatment options for sleep disorders include sleep hygiene, cognitive behavioral therapy, medication, and addressing contributing factors.
- Sleep is also affected by factors such as travel fatigue and jet lag, which should be taken into consideration for athletes.

DEFINITIONS

Sleep disorders refer to a group of conditions that affect a person's ability to get adequate sleep. Some common examples include insomnia, sleep apnea, restless leg syndrome (RLS), and narcolepsy. These conditions can have a significant impact on a person's overall health and well-being, leading to fatigue, irritability, and an increased risk of health problems.[1–3]

Insomnia

Insomnia is a sleep disorder characterized by difficulty falling or staying asleep, despite having adequate opportunity and circumstances, and must be associated with negative impact of daily activities or mood-related symptoms.[4,5] People with insomnia may also experience difficulty concentrating, irritability, mood swings, and

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a decrease in overall quality of life. Insomnia can be caused by a variety of factors including stress, anxiety, depression, poor sleep hygiene, medications, and medical conditions.[6] A diagnosis of insomnia is established when the patient expresses dissatisfaction with sleep on at least 3 nights per week over a period of more than 3 months, along with accompanying symptoms such as daytime drowsiness, reduced attention span, and mood changes. A polysomnogram (PSG) may also be conducted to rule out other sleep disorders and to evaluate the patient's sleep patterns.

Sleep Apnea

Sleep apnea is a disorder characterized by repeated episodes of interrupted breathing during sleep. The symptoms of sleep apnea include loud snoring, pauses in breathing during sleep, choking or gasping during sleep, and difficulty staying asleep.[7] It can also lead to daytime sleepiness, morning headache, dry mouth, and difficulty concentrating. Sleep apnea can lead to serious health problems if left untreated, such as high blood pressure, heart attack, stroke, diabetes, and depression.[8] It is also important to note that sleep apnea can occur in people of all ages and is not limited to older adults or overweight individuals. Sleep apnea is caused by a partial or complete blockage of the airway during sleep. This blockage can be caused by a variety of factors, including obesity, a large tongue or tonsils, and is associated with family history of sleep apnea. It is typically diagnosed based on a patient's reported symptoms and a PSG.[7]

Restless Leg Syndrome

RLS is a neurologic disorder characterized by an irresistible urge to move the legs, often accompanied by unpleasant sensations such as tingling, creeping, crawling, or aching. The symptoms typically occur at night and can disrupt sleep, leading to daytime fatigue and impaired quality of life. The exact cause of RLS is unknown, but it is believed to be related to a deficiency of dopamine, a neurotransmitter that plays a role in movement and sensation. Other factors that may contribute to the development of RLS include iron deficiency, peripheral neuropathy, kidney failure, pregnancy, and certain medications.[9] The diagnosis of RLS is made through a clinical history and is often accompanied by periodic limb movements in sleep (PLMS). PLMS is present in 80% to 90% of RLS patients and can be confirmed with a PSG if necessary. Owing to the absence of a reliable biological diagnostic marker for RLS, the clinical assessment, especially the acquisition of the patient's medical history, plays a vital role in accurately diagnosing this condition.[9]

Narcolepsy

Narcolepsy is a disorder characterized by excessive daytime sleepiness along with other symptoms such as cataplexy (sudden loss of muscle tone), sleep paralysis, and vivid hallucinations during sleep onset or wakefulness. The primary cause of narcolepsy is a deficiency in the neurotransmitter hypocretin (also known as orexin), which regulates wakefulness and rapid eye movement (REM) sleep.[10] The diagnosis of narcolepsy is typically made by a sleep specialist through a combination of patient history, physical examination, and sleep studies such as PSG and multiple sleep latency test.[5]

NATURE OF THE PROBLEM
Sleep Disorders in the General Population

Sleep disorders are common among the general population, with a significant number of people experiencing difficulty sleeping. According to data from the National Center for Health Statistics, approximately 50 to 70 million adults in the United States have a

sleep disorder.[11] Insomnia is the most common sleep disorder, with an estimated 30% of adults experiencing symptoms of insomnia at some point in a given year and roughly 10% of the adult population meeting the criteria for insomnia disorder. Sleep apnea affects an estimated 25 million people in the United States, with 80% of moderate to severe cases remaining undiagnosed and higher rates observed in men and older adults[12] RLS affects around 2% to 10% of adults, whereas narcolepsy is estimated to affect one in 2000 people in the United States.[12] However, the prevalence of sleep disorders can vary widely depending on the population studied and the diagnostic criteria used. It is also not uncommon for people to experience multiple sleep disorders at the same time.

Sleep Disorders in Athletes

The prevalence of sleep disorders in athletes has received increased attention in recent years, with research suggesting that athletes may be at higher risk for certain sleep disorders due to factors such as training schedules, travel, and competition stress. Although research in the field is still limited, studies have suggested that athletes have higher rates of insomnia symptoms compared with the general population.[13] This may be caused by the physical and mental exertion aspects of sports training. In addition, certain athletes (especially those in contact sports such as rugby and American football) may have physical attributes such as a higher body mass index or larger neck circumference and the altered upper airway dynamics that come with it, which may lead to a higher risk of obstructive sleep apnea (OSA).[14]

Another aspect that may be common for athletes to face is the sleep disorders that can be caused by the psychological stress of competition and the pressure to perform. Athletes may experience insomnia, anxiety, and depression that can affect their sleep patterns.[15]

Gender Differences

There are some differences in sleep patterns and disorders between men and women, which may be influenced by a variety of factors including hormonal, physiologic, and lifestyle differences. Women are 1.4 times more likely to experience insomnia than men.[16] Women are also more likely to experience sleep-related movement disorders, such as RLS.[17] On the other hand, sleep-disordered breathing, such as OSA, is more prevalent in men than women.[18]

Although sleep disorder disparities between men and women are apparent in the general population, research on elite athletes has produced conflicting results. Studies have shown that women had a higher prevalence of sleep disorders, specifically difficulty initiating and maintaining sleep, and male athletes had longer total sleep times than female athletes.[19,20] However, other research found that men who competed at an elite level had more sleep complaints than women.[21]

CLINICAL RELEVANCE

Sleep is essential for maintaining physical and mental health and well-being. Adequate sleep is important for the proper functioning of the body's systems and plays a crucial role in the healing and repair of the heart and blood vessels, muscles, and other tissues.[22]

General Health Benefits

Maintaining a healthy immune system that can defend against infections and illnesses requires sufficient sleep.[23] The regulation of the body's metabolism is another

essential function of sleep, which is important for maintaining a healthy weight and preventing chronic diseases such as obesity, diabetes, and heart disease.[24]

Cognition

Sleep plays a critical role in cognitive function and brain health. Some of the cognitive benefits of sleep include.

Memory consolidation: Sleep helps to consolidate and solidify memories, allowing them to be stored and retrieved more easily. Sleep plays a crucial role in the consolidation of both declarative and procedural memories.[25]

Learning and cognitive flexibility: Adequate sleep is essential for learning new information and skills and for being able to adapt to new situations. Sleep-deprived individuals have difficulty adapting to new information and learning new tasks.[26]

Improved attention, reaction time, and decision-making: Sleep deprivation can lead to decreased attention and reaction time, impaired judgment, and increased accident risk.[27]

Problem-solving and creativity: Sleep is essential for the brain to be able to process information and find new solutions to problems. Sleep-deprived individuals have difficulty solving problems and coming up with new ideas.[28]

Emotional regulation: Sleep also plays a role in regulating emotions, which can affect cognitive processes such as decision-making, problem-solving, and attention.[29]

Injury Reduction

Insufficient sleep can lead to slower reaction times, decreased attention, and impaired judgment, all of which can lead to greater risk of sports and musculoskeletal injuries.[30] Less than 8 hours of sleep per night was associated with higher injury risk in high school athletes.[31] Most evidence points to chronic sleep deprivation having a larger impact than acute sleep issues.[30] It has been suggested that there is a link between sleep extension and enhancement of muscle injury recovery via the boosting of Insulin-like Growth Factor 1 (IGF-1) levels and potential regulation of localized inflammation.[32]

Athletic Performance

Sleep is critical for not only physical and mental health but for optimal athletic performance. Some of the demonstrated effects of sleep on performance include:[33,34]

Endurance: Sleep deprivation is associated with an increase in perceived exertion and decreased time to exhaustion.

Anaerobic power: Sleep deprivation leads to decreased mean and peak power output during the Wingate test (a cycle ergometer test that measures anaerobic capacity and power output).

Accuracy: Sleep extension improved basketball free throw and three-point field goal percentage. Sleep restriction decreased tennis serve and dart-throwing accuracy.

Mental Health and Sleep

The relationship between mental health and sleep is bidirectional and complex. The interconnected nature of the two can pose a challenge to the physician, but it is important to assess both and take steps to treat any problems identified. The stress of performance and competition can impact sleep in athletes. Some theories suggest a hormonal mechanism. Salivary cortisol levels and perceived stress are higher following competition compared with training and rest days and this was accompanied by reduced sleep quantity and quality.[35]

Anxiety and depression: Some data suggest that order of onset can vary based on the type of mental health disorder. In young adults, anxiety was more likely to precede insomnia, whereas depression more commonly had a later onset than insomnia.[36] Treating anxiety and depression with cognitive behavioral therapy can improve insomnia severity.[37]

Suicidal ideation: Suicidal thoughts are more prevalent in athletes with sleep disorders, such as onset insomnia and insufficient sleep (not getting enough sleep to feel rested).[38]

Eating disorders: The prevalence of sleep disturbance in patients with eating disorders is greater than 50%, and patients with a higher binge frequency were more likely to have sleep difficulties.[39]

Attention-deficit hyperactivity disorder: Adolescents with attention-deficit hyperactivity disorder have a longer sleep onset and shorter sleep duration than age-matched controls.[40]

APPROACH

Taking a detailed sleep history allows physicians to best determine diagnosis and treatment of sleep disorders.

Basic Sleep History Questions

To better understand the sleep habits of an athlete, the following issues should be addressed when evaluating an athlete according to the National Collegiate Athletic Association (NCAA) Interassociation Task Force on Sleep and Wellness:[41]

- Bedtime
- Wake time
- How long it takes to fall asleep
- Nap frequency, timing, and duration
- Sleep quality
  - Number of nightly awakenings and reason
  - Issues with sleep onset or sleep maintenance
  - Waking feeling rested
  - Daytime sleepiness
- Sleep disorders
  - Hallucinations, sleep paralysis, or cataplexy
  - Nighttime leg discomfort relieved by movement
  - Sleep walking or night terrors
  - Snoring, witnessed apnea, choking, gasping, or shortness of breath
- Medication and drug use
  - Stimulants (prescription medications, caffeine)
  - Sedative hypnotics
  - Drug and alcohol use
- Mental health status
- Environmental conditions
  - Exposure to light
  - Electronic device use

Athlete-Specific Questions

High-level athletes experience unique circumstances that may affect their sleep. Inquiring about these topics will help the physician understand potential barriers to adequate sleep. Examples include.

- What time of day do you typically train?
- Do you have any current injuries or pain that affect your sleep?
- Is fear of reinjury or reliving a traumatic event on your mind often?
- Does worrying about playing time or performance affect your ability to sleep?
- How often do you travel for games/training?
- Is your sleep worse when you are away from home?
- Do you travel to other time zones?
- Does your sleep vary in relation to being in-season versus out-of-season?

Advanced Questions

Although the above sleep history suggestions will address the majority of sleep difficulties, a physician may need to consider less common causes if the source of sleep difficulty cannot be determined.

Diet: Meals high in protein may improve sleep quality, and diets high in fat may shorten the duration of sleep.[42,43] Hidden sources of caffeine may also be uncovered as some sports drinks now contain caffeine.

Eating disorders: Although female athletes and those in esthetic and endurance sports are at higher risk of developing disordered eating/eating disorders, any athlete can have an eating disorder or low energy availability.[44] Malnutrition increases orexin, a hormone that promotes wakefulness.

Food insecurity: Greater odds of depression, anxiety, and suicidal ideation as well trouble falling asleep and staying asleep are seen in people who deal with food insecurity.[45] This could be easily missed as athletes may not be forthright about difficulty affording adequate nutrition.

Menstrual cycles: Premenstrual and menstrual periods are associated with insomnia and poor sleep quality.[46] Premenstrual syndrome is associated with symptoms such as headaches and mood disturbances which may impact sleep. The luteal phase is associated with poor sleep quality and daytime sleepiness, possibly due to changes in melatonin and body temperature.[47]

Mental health: Although screening for anxiety and depression is common in athletes, attention should also be paid to disorders such as schizophrenia, bipolar disorder, or post-traumatic stress disorder (PTSD). PTSD can occur in athletes after musculoskeletal injuries but asking about recent concussions can also be helpful.[48]

Overtraining syndrome: Athletes with fatigue, muscle soreness, reduced performance, sleep disturbance, and mood changes may be dealing with overtraining syndrome.[49] Asking about training volume and recovery strategies may help uncover this diagnosis.

Medical conditions: Asthma and gastroesophageal reflux disease are common medical conditions that can have an impact on sleep, especially when they are not adequately treated.[50]

EVALUATION

If a sleep disorder is suspected, the physician must decide the best way to evaluate the athlete to provide a diagnosis or determine the factors contributing to their problem.

Polysomnography

Considered the gold standard for diagnosing sleep problems, PSG is used to capture physiologic characteristics such as brain activity, muscle activity, eye movement, and heart activity during sleep. It also provides information on sleep onset latency, wake after sleep onset, sleep efficiency, frequency of sleep awakenings, and sleep

fragmentation. In addition, both REM sleep and non-REM sleep can be evaluated. Some less desirable aspects of PSG include high cost, needing specialized equipment and a laboratory environment with a trained technician, and sleeping in a foreign location that may not accurately mimic the home sleep environment, thus skewing outcomes.

Actigraphy

Actigraphy is a method for determining sleep and wake patterns based on movement data collected by a device that may be worn on the wrist or ankle and is less expensive and easier to wear than PSG. It is possible to evaluate total sleep time, sleep-onset latency, waking after sleep onset, and sleep efficiency. It is recommended that the device is worn for at least 5 days, and measurements are usually taken every minute.[51] Actigraph data can be incorrect if the device is worn inconsistently as lack of motion when not attached to the person can be interpreted as sleep. It also tends to overestimate total sleep time because it is hard to detect brief awakenings.

Sheet Sensors

Sheet sensors were first used in nursing homes or by the elderly living alone. A device is placed under the sheet to detect sleep/wake patterns, heart rate, body movement, and respiration patterns. However, because it can only be used while an individual is sleeping in the bed, this option may miss naps taken in locations other than the bed or nights where the person sleeps away from their home.[52] It is inexpensive, inconspicuous, and longitudinal data can be obtained.

Smartphone Applications

Owing to the increase in smartphone usage, there are numerous sleep measurement applications.[53] Most are required to be placed on the bed and measure the subject's movement using the smartphone's integrated sensors or some can record sounds to evaluate sleep. However, evidence is scant and additional research is required, particularly to confirm the application's quality compared with PSG or other well-studied techniques.

Sleep Diaries

Sleep diaries are cost-effective and should normally be kept for at least 1 week. Athletes should record their bedtime and waking time, daytime napping, assessments of drowsiness and alertness, caffeine and alcohol use, and use of light-emitting devices before going to bed. However, they may be subjective and, because they are generally based on memory, are not always accurate.

Questionnaires

Questionnaires may be subjective, but they are frequently used to evaluate the sleep habits and disorders of athletes due to being cost-effective. They can be the best option for mass screening of large athlete populations. Commonly used questionnaires include:

Athlete Sleep Behavior Questionnaire: The Athlete Sleep Behavior Questionnaire (ASBQ) is also for athletes and consists of 18 questions that examine sleep behavior using a five-point scale. Three main categories included are routine/environmental factors (naps, consistent bedtimes, travel), behavioral factors (medications, alcohol, and late-night technology use), and sport-related factors (late night training, pain, and worrying about performance). A higher global score suggests a larger risk of poorer sleep-related behaviors; the investigators of the ASBQ advise that a global score $\leq$ 36 corresponds to "excellent" sleep behavior, 37 to 41 corresponds to

"moderate" sleep behavior, and ≥ 42 corresponds to "bad" sleep behavior. The ASBQ has demonstrated low-to-moderate correlations with other sleep questionnaires and high test–retest consistency.[54]

Athlete Sleep Screening Questionnaire: The Athlete Sleep Screening Questionnaire is a survey that is designed to assess athletes for clinical sleep disorders and suggest if further workup is needed using 16 questions. A "Sleep Difficulty Score" (SDS) is calculated using five questions based on total sleep time, satisfaction with sleep, use of medicine to help sleep, and the presence of insomnia symptoms. The SDS is paired with several additional questions assessing chronotype and sleep-disordered breathing.[55] The SDS was incorporated into the International Olympic Committee's (IOC) Sport Mental Health Assessment Tool 1 to screen for mental health symptoms and disorders.[56]

Epworth Sleepiness Scale: The Epworth Sleepiness Scale is a questionnaire used to assess daytime sleepiness. Questions evaluate the likelihood of falling asleep in various situations such as reading, watching TV, or riding in a car.[57] This is not specific to athletes.

Insomnia Severity Index: Insomnia Severity Index consists of seven questions investigating difficulty falling asleep, staying asleep, and waking early as the impact of sleep on quality of life over a 2-week period.[58] This is not specific to athletes.

Pittsburgh Sleep Quality Index: This is used to evaluate sleep length, habitual sleep efficiency, sleep latency, sleep disruption, daytime dysfunction, sleep medication use, and subjective sleep quality. Participants are asked to rate the frequency of each item over the preceding month. The questions are not athlete-specific but have been validated in many languages.[59]

TREATMENT

Addressing sleep difficulties in athletes involves targeting deficiencies and treating co-morbid conditions.

Sleep Hygiene

Educating athletes on proper sleep hygiene is almost always the first step of addressing sleep disorders. This can be done via handouts to large groups or one-on-one sessions if time and resources allow. The NCAA Interassociation Task Force on Sleep and Wellness recommend following these sleep hygiene guidelines:[41]

- Maintain a regular sleep schedule
- Seek bright light during the day and avoid bright light at night
- Keep the sleep environment cool, dark, and comfortable
- Avoid caffeine at least 6 hours before bedtime
- Avoid excessive food and liquids at night
- Avoid obsessive clock watching
- Consider avoiding naps, although some people may function better with naps so this recommendation may vary on an individual basis
- Use beds for sleep only

Cognitive Behavioral Therapy

Cognitive behavioral therapies are beneficial and are extensively used for insomnia.[60] Cognitive behavioral therapy for insomnia (CBTI) is a structured program that identifies and replaces sleep-disrupting thoughts and actions with sleep-promoting routines. The patient can learn how to support and naturalize the body's sleep process, resulting in long-term improvements. CBTI consists of sleep restriction, stimulus control, cognitive therapy, sleep hygiene training, and relaxation training. CBTI is a safe and

highly effective treatment for insomnia, but it may be underused due to a shortage of skilled CBTI practitioners and because athletes' busy schedules may make it difficult for them to attend therapy sessions. Thus, physicians and medical practitioners can play a role in educating athletes about the significance and benefit of CBTI.[61]

Medications and Anti-Doping Considerations

Both the NCAA and the IOC recommend CBTI over medication when treating sleep disorders in athletes.[41,62] With that said, some athletes use medication despite a lack of high-level research on efficacy in their population. Over-the-counter melatonin is a common treatment, often acquired by athletes without seeing a physician. Melatonin receptor agonists and benzodiazepine receptor agonists (BZRAs) are used for sleep-onset disorders, whereas dual orexin receptor antagonists, low-dose doxepin, and BZRAs are used for sleep-maintenance insomnia.[63] Some off-label prescription medications are used such as sedating antidepressants and gabapentin, although these are probably most effective when being used to also address concomitant mental health or pain conditions.[63] Owing to the sedating nature of many of these medications, the athlete should monitor for side effects that may carry over to the next day and impact training.[64] Stimulants, sometimes prescribed to treat daytime drowsiness, are prohibited by World Anti-Doping Agency (WADA) and steps need to be taken to assure that compliance with all WADA documentation occurs.

Lifestyle Changes

Sleep disorders including sleep apnea and RLS can be treated with lifestyle changes. For sleep apnea, this may include weight loss, exercise, and avoiding alcohol and sedatives. In patients with RLS, regular exercise and avoiding caffeine and alcohol as well as medications such as dopaminergic drugs, iron supplements, and anticonvulsants are recommended.[65]

Continuous Positive Airway Pressure

The treatment of sleep apnea typically involves a combination of lifestyle changes and medical devices. Continuous positive airway pressure (CPAP) machines deliver air pressure through a mask and oral appliances reposition the jaw to help keep the airway open. Surgery, which may help to remove or shrink excess tissue in the airway that may be causing the blockage, may also be an option for some individuals with sleep apnea if CPAP and lifestyle changes do not work.[66]

CONSIDERATIONS
Travel Fatigue

Travel fatigue is a combination of physical, physiologic, and psychological issues leading to exhaustion and tiredness and can occur from various modes of travel (bus, train, and airplane). Some proposed contributors to travel fatigue include restricted movement, impaired nutritional intake, concerns about travel logistics, disruption of daily routine, and noise stress. The four key factors of travel fatigue severity are total distance traveled, time of travel, frequency of travel, and time available for recovery.[67] Travel fatigue can occur without crossing time zones and is a separate entity than jet lag (explained below). Symptoms of travel fatigue include persistent fatigue, recurrent illness, behavior and mood changes, and loss of motivation. Management of travel fatigue is multifactorial. Pretravel athletes should be as well rested as possible and plan their nutrition and hydration in advance. During travel, it is important to move frequently and stretch when possible, consider noise-

cancelling headphones, and follow illness prevention strategies such as hand washing.[67]

Jet Lag

Jet lag is a "temporary impairment of sleep and wakefulness, as well as other biological functions, associated with rapid eastward or westward travel across 3 or more time-zones."[67] This is due to a circadian desynchronization between the athlete's internal clock and the external cues of the new time zone. The severity of jet lag is affected by number of time zones traveled and travel direction (eastward vs westward). Ideal performance likely occurs during daytime of the time zone the athlete came from and evaluation of professional athletes suggests that traveling westward for an evening competition gives the greatest disadvantage.[68] Symptoms of jet lag include daytime sleepiness, sleep disruption, and lack of concentration.[67] One validated tool that can be used to assess the effect of trans-meridian travel on athletes is the Liverpool Jet Lag Questionnaire.

Jet lag can be explained in part by two markers of circadian rhythm. First, core body temperature (CBT) in the human body has daily fluctuations. Sleep can be initiated most easily when CBT is low or falling. Conversely, when CBT is high or rising it is difficult to sleep.[67] Second, melatonin is a hormone that aids with sleep and is typically secreted approximately 2 hours before habitual bedtime (often referred to as dim light melatonin onset).[67] Traveling across times zones creates a mismatch in timing of CBT and melatonin which can impact ability to fall asleep and stay asleep.

Two commonly proposed solutions to jet leg are light exposure and melatonin.[69] Although some assume that bright light in the morning and melatonin before bedtime will help manage jet leg, timing of these interventions is complex and depends on eastward versus westward travel.[67] Light exposure and exogenous melatonin recommendations can be found in sleep publications, although evidence behind these recommendations is low quality.[67,69,70] Other suggestions for assisting with phase shifting or combating symptoms of jet leg include exercise, caffeine, strategic napping, and following good general sleep hygiene practices.[67,69]

CLINICS CARE POINTS

- Evaluation of an athlete's sleep involves taking a thorough sleep history but ruling out contributions from medical conditions such as sleep apnea, asthma, and gastroesophageal reflux disease.
- When screening large groups of athletes for sleep disorders, consider the Athlete Sleep Screening Questionnaire or Athlete Sleep Behavior Questionnaire, athlete-specific questionnaires.
- Cognitive behavioral therapy for insomnia is recommended as a first-line treatment for insomnia over medications by prominent sporting organizations including both the National Collegiate Athletic Association and International Olympic Committee.
- Understanding the effects of jet lag and travel fatigue, and creating plans in advance for athletes who travel frequently, will optimize health and performance.

DISCLOSURE

The authors have nothing to disclose.

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