

Dairy and Sleep

from folklore to science

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Summary Points

- Sleep is a modifiable factor that supports health, contributing to both physiological and psychological functions. Insufficient sleep is a largely unrecognised public health problem globally. The circadian system responds to many signals including the light-dark cycle, food intake, temperature, physical activity, drugs and stress.
- Dietary components can act on neurotransmitters which influence sleep, and likewise, sleep deprivation can influence metabolic hormones and appetite. This relationship between food and the internal circadian clock is referred to as chrononutrition.
- Current research indicates that dairy has positive effects on sleep. Cow's milk protein is rich in tryptophan, which is a precursor for both serotonin and melatonin. These hormones play important roles in the regulation of sleep. Small amounts of melatonin also occur naturally in cow's milk.
- Fermented milk has been shown to significantly improve sleep efficiency. Lactic acid bacteria present in fermented dairy produce gamma-aminobutyric acid, a neurotransmitter which is associated with sleep. Calcium inadequacy is associated with poor sleep and therefore, the calcium component of dairy may be another factor which influences sleep.
- The overall composition of milk also makes it a nutritious bed-time drink. It provides casein-rich protein, which is encouraged as a pre-sleep intervention strategy to increase muscle protein synthesis overnight for both athletes and older people.

Editorial

Warm milk before going to bed is a tradition that has been passed down through generations as a practice to facilitate a restful night's sleep.

As with other bedtime routines, it may be the ritual itself that helps to induce the anticipation of sleep. Also, drinking milk before falling asleep could be associated with soothing, early childhood memories that evoke calmness. However, it is also believed that naturally occurring components in milk can support the process of sleep.

In this edition of DN Forum, we introduce the science of sleep and explore the research on how food interacts with sleep and the circadian system. We will focus specifically on the scientific evidence which examines the role of milk and dairy products.

We hope you enjoy this edition of DN Forum and look forward to any feedback or comments you wish to share: nutrition@ndc.ie



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INTRODUCTION

Sleep has been identified as a key component of a healthy lifestyle along with diet and exercise¹. The classic view of sleep is as a recovery process, which contributes to both physiological and psychological function^{2,3}. It is an active anabolic state and therefore promotes growth, cellular repair and regeneration, energy restoration, and stimulation of the immune system^{4,5}. On a global scale, insufficient sleep is prevalent and considered to be a largely unrecognised public health problem, with under-reported economic costs⁶. As with nutrition and physical activity, sleep is a modifiable factor for promoting health and therefore, the interactions between sleep, nutrition and physical activity are also important⁷.

The restorative benefits of sleep are dependent on both sleep quality and duration. Sleep has two basic stages: non-rapid eye movement sleep (NREM) and rapid eye movement (REM) sleep⁸. Both of these stages are as distinct from one another as they are from wakefulness⁹. NREM sleep is divided into three sub-stages; the deepest stage (known as deep, slow-wave or delta-sleep) is the stage which is most difficult to wake from¹⁰. It is also the phase which is mostly associated with recovery and immune function. In contrast, REM sleep is mostly associated with cognitive functions such as memory, learning and creativity. It is associated with dreaming, while brain mechanisms inhibit spinal motor-neurons and limit movement. Hence, REM sleep has been defined as a highly-activated brain in a paralysed body⁹.

Given the intricate role that sleep plays in health and the potential interactions with nutrition, this review aims to explore what it known about food and sleep. Having a glass of milk or warm milk before bed is a tradition that has long been associated with a restful night's sleep. The research on dairy and sleep specifically will be examined, to determine whether this practice is simply folklore or if there is any scientific basis to support the role of milk as a bedtime drink.

SLEEP AND HEALTH

The National Sleep Foundation has produced guidelines regarding sleep duration recommendations, which change over the lifespan (Table 1)¹¹.

Whilst there is continuing debate in the literature regarding the exact function of sleep, the importance of sleep is clear as it plays a role in a myriad of physiological processes. Several aspects of cardiovascular health^{12,13} and immune function¹⁴ have been associated with sleep. Irregular sleep patterns and sleep deficiency have been identified as an independent risk factor for CVD¹⁵, morbidity and all-cause mortality¹⁴. Sleep disturbances (difficulty initiating or maintaining sleep) and sleep deprivation (not getting enough sleep) are also recognised as risk factors for inflammation and immune related illness^{11,16,17}.

Sleep also has a role to play in endocrine function as sleep deprivation can contribute to imbalances in growth hormone, thyroid hormone, adrenaline, cortisol, testosterone and IGF-1^{18,19}. It has been



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hypothesised that sleep, especially deep sleep, is vital for physiological recovery, which is related to growth hormone release^{8,20}. Growth hormone directly results in increased amino acid uptake, increased ribonucleic acid (RNA) synthesis, increased protein synthesis, increased cartilage synthesis and hypertrophy²¹. In addition, sleep deprivation has been associated with impaired insulin sensitivity and glucose homeostasis²². It also has a key role in the replenishment of energy stores that facilitate improved immune responses, with adaptive immunity peaking during sleep²³.

Cognitive recovery also takes place during sleep. It has been suggested that sleep accommodates skill development, learning, memory, synaptic plasticity and psychological recovery^{14,24,25}. Sleep deprivation adversely affects mood state²⁶, and mood state can be enhanced through sleep extension (> 10 hours per night)²⁷.

Population	Recommended (h)	Adequate (h)	Not recommended (h)
Adolescents	8 - 10	7 - 11	< 7; > 11
Adults (18 - 64 years)	7 - 9	6 - 11	< 6; > 11
Older adults (≥ 65 years)	7 - 8	5 - 9	< 5; > 9

(Adapted from: Hirshkowitz *et al.* 2015¹¹)

Table 1: Guidelines for sleep duration.

SLEEP, FOOD AND CHRONONUTRITION

The circadian system responds to various signals, including the light-dark cycle, food intake, temperature, physical activity, drugs and psycho-social stress. While light information obtained from the retina is a key synchroniser of circadian systems in mammals, the impact of food has been shown to have comparable effect^{28,29}.

Chrononutrition refers to the relationship between food intake and the internal circadian clock system and to how this system can be altered by changing the timing of food intake³⁰. Neurotransmitters in the brain such as serotonin, gamma-aminobutyric acid (GABA), orexin, melanin-concentrating hormone, cholinergic, galanin, noradrenaline and histamine are involved in the sleep-wake cycle and therefore, nutritional interventions that act upon these neurotransmitters may influence sleep³¹. Sleep deprivation can also impact appetite and glucose metabolism due to its influence on leptin (appetite suppressant) and ghrelin (appetite stimulant)³².

Tryptophan is an amino acid found in many foods, with good sources including milk, chicken, turkey and peanuts. It acts as a precursor to serotonin and melatonin, which are important hormones in the regulation of the sleep-wake cycle⁸. Early research concluded there was a significant positive effect of tryptophan (doses ≥ 1g) on sleep latency (time taken to fall asleep)³³. However, tryptophan may have

minimal effects on sleep in healthy adults who fall asleep easily. Tryptophan depletion studies have demonstrated that decreased plasma tryptophan concentrations were associated with sleep fragmentation compared to baseline and placebo^{34,35}. Melatonin is mainly secreted by the pineal gland at night and is largely recognised as a sleep facilitator³⁶. While it can be synthesised from tryptophan-rich foods, melatonin is also available as an oral supplement, which is often used for short-term treatment of insomnia. It has very low toxicity even at relatively high doses, but there appears to be no added benefit to doses > 3 mg³⁷.

Dietary interventions such as high carbohydrate (high glycaemic index) evening meals; melatonin; tryptophan-rich protein; tart cherry juice; and kiwifruit, have all been shown to improve sleep³⁸. It is well recognised that caffeine increases the state of alertness and can therefore lead to poor sleep. Alcohol consumption has also been associated with poorer sleep quality and quantity, with increased sleep disturbance in the second half of the sleep cycle³⁹.

DAIRY AND SLEEP

Cow's milk has traditionally been considered as a sleep promoting beverage. The milk protein, α -lactalbumin has been reported as having the highest natural levels of tryptophan among all protein food sources⁴⁰. In a study of healthy adults with sleep complaints, those who consumed milkshakes containing 20 g of α -lactalbumin showed a modest but significant reduction in sleepiness and improved alertness the following morning, compared to a placebo⁴¹.

Melatonin occurs naturally in cow's milk, although the concentration can vary in relation to seasonality and time of day. In one study, an average concentration of 6.98 pg/ml was reported, while milk produced at night and in the winter had a concentration of 41.94 pg/ml⁴². Whether these concentrations are adequate to have any biological effect is inconclusive, but a review on the influence of food sources of melatonin on sleep indicated that milk may improve sleep quality in humans⁴³. Due to its higher concentration of melatonin, 'night-time milk', from cows milked in the evening, is often promoted to aid sleep or relaxation.

A study investigating difficulty initiating sleep (> 30 mins to fall asleep) in older adults demonstrated that consumption of milk or cheese, in combination with sufficient physical activity, reduced difficulty initiating sleep⁴⁴. Lactic acid bacteria present in fermented dairy products such as cheese and yogurt produce gamma-aminobutyric acid (GABA). GABA is an inhibitory neurotransmitter, which is also synthesised by mammals during sleep and poor sleep reduces GABA production. Therefore, GABA is thought to be involved in the improvement of sleep quality observed following consumption of fermented dairy⁴⁵. A randomised control trial of fermented milk (100 g) was shown to significantly improve sleep efficiency and decrease frequency of waking after sleep onset in older adults⁴⁶.

In children and adolescents, consumption of milk and yogurt were associated with adequate sleep duration⁴⁷. A study of over one thousand university students showed that low dairy intake was associated with higher prevalence of psychological and sleep disturbances⁴⁸. Frequency of milk and dairy consumption in relation to sleep quality was also explored in a group of elite Japanese athletes⁴⁹. After adjusting for confounders, milk consumption among female athletes was significantly associated with better subjective sleep quality during training⁴⁹.

Research has demonstrated that low calcium intake is associated with difficulty falling asleep and has a negative impact on sleep quality⁵⁰. As milk and dairy products are recognised as an excellent

source of calcium, this may be another mechanism linking dairy with improved sleep.

Extending from nutrition to psychology, the impact of food on dreaming is another interesting element within the area of food and sleep. Beliefs about how food can influence dreams have circulated for millennia⁵¹. The effects of food on dreaming remain largely in the realm of speculation. The theory that cheese is associated with nightmares or bizarre dreams is thought to have originated from 'Dream of the Rarebit Fiend', a comic strip from the early 1900s, where the spicy cheese dish was responsible for bizarre and disturbing dreams. In an observational study exploring the relationship between food and dreams, dairy products were the most common perceived instigator of both disturbing (44%) and bizarre (39%) dreams⁵¹. However, evidence that food directly affects dreaming is scarce, and there is no data to verify a causal relationship with cheese.

MILK AS A BEDTIME DRINK

Apart from being a source of tryptophan, melatonin, GABA and calcium, which are all associated with improved sleep, milk as a bedtime drink provides a host of other important nutrients. A 200 ml glass of whole milk is less than 130 kcal and provides 7 g of protein, along with calcium (31% of RI); vitamin A (10% of RI); riboflavin (34% of RI); vitamin B5 (20% of RI); vitamin B12 (74% of RI); iodine (43% of RI); potassium (16% of RI); phosphorus (28% of RI); and zinc (10% of RI).

The composition of milk proteins is approximately 20% whey and 80% casein. Casein is considered a 'slow release' protein, which means it is emptied at a slower rate from the stomach, allowing for a more prolonged rise in levels of plasma amino acids⁵²⁻⁵⁴. For this reason, casein-rich protein ingestion prior to sleep is considered an effective interventional strategy to increase muscle protein synthesis rates during overnight sleep and can be applied to support the skeletal muscle adaptive response to both resistance-type exercise training and to preserve muscle mass in the elderly^{55,56}.

Due to its composition and the related hydrating value of milk, it produces lower urinary output compared to water^{57,58}. Therefore, it may be a more suitable evening drink for older people or those who wake regularly due to a need to urinate. The tradition of milk as a bedtime drink generally encourages warm milk, but there is no evidence to suggest any nutritional advantage. However, from a sensory perspective, gently warmed milk may offer a more soothing or calming feeling.

CONCLUSION

Chrononutrition is an exciting area of discovery in the relationship between nutrition and sleep. Further research involving food and dietary components is necessary to clarify the interactions between nutrition and the circadian system as there may be potential to reduce the prevalence and burden of chronic disease risk, through promotion of better sleep. While more longitudinal research is necessary to investigate the effects of dairy on sleep quality and duration in various populations, the current research indicates that consumption of milk and dairy products has positive effects on sleep quality and duration.

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Mission:

To deliver real and unique value to Irish dairy farmers by protecting and promoting the image, quality, taste and nutritional credentials of Irish dairy produce to a wide variety of audiences in a clearly defined, focused and effective manner.

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