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Strategies of Functional Foods Promote Sleep in Human Being

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Abstract: Sleep is a vital segment of life, however, the mechanisms of diet promoting sleep are unclear and are the focus of research. Insomnia is a general sleep disorder and functional foods are known to play a key role in the prevention of insomnia. A number of studies have demonstrated that major insomnia risk factors in human being are less functional foods in dietary. There are higher functional components in functional foods promoting sleep, including tryptophan, GABA, calcium, potassium, melatonin, pyridoxine, L-ornithine and hexadecanoic acid; but wake-promoting neurochemical factors include serotonin, noradrenalin, acetylcholine, histamine, orexin and so on. The factors promoting sleep in human being are the functional foods include barley grass powder, whole grains, maca, panax, Lingzhi, asparagus powder, lettuce, cherry, kiwifruits, walnut, schisandra wine, and milk; Barley grass powder with higher GABA and calcium, as well as potassium is the most ideal functional food promoting sleep, however, the sleep duration for modern humans is associated with food structure of ancient humans. In this review, we put forward possible mechanisms of functional components in foods promoting sleep. Although there is clear relevance between sleep and diet, their molecular mechanisms need to be studied further.

Keywords: Bioactive component, dietary, functional food, human being, insomnia, molecular mechanisms, sleep promoting.

INTRODUCTION

Sleep affects brain function, which is not only a common phenomenon in vertebrates, but is also as a result of environmental, psychophysiological and pharmacological factors and remains one of the mysterious sciences. Sleep disorders (insomnia and so on) constitute a global epidemic that affects 45% of the world's population [1], but less than 1% have been treated by functional foods for insomnia prevention; sleep disorders cost the US $150 billion each year. Insomnia qualifies to be the world's most common sleep disorder affecting 2.2 billion in 2014, which accounts for 30% of the population of the world. The pathogenetic mechanism of insomnia or agrypnia constitutes visceral thalamus degeneration (familial insomnia), autoantibodies blocking the voltage-gated potassium channels and GABAergic synapses down-regulated within the limbic system [2].

Dietary supplementation of tryptophan can stimulate serotonergic activity and promote sleep, whereas serotonin released into diencephalon and cerebrum might play a key inhibitory role in insomnia prevention [3]. Prolonged-release melatonin was approved in Europe for insomnia prevention, which suggest a beneficial role of sleep-wake cycle stabilization in the treatment of insomnia [4]. Benzodiazepines for rapidly modulate GABA signaling in central neurons are widely used in the treatment of a variety of neurological and psychiatric conditions including anxiety, insomnia and epilepsy [5]. FDA-approved medications for treatment of chronic insomnia include γ-aminobutyric acid (GABA), melatonin, benzodiazepine, and histamine 4 receptor agonist [6]. T-type calcium channels have been proposed as therapeutic targets for lots of diseases such as insomnia, epilepsy, pain, cancer and hypertension [7]. The immunoglobulin G targeting dipeptidyl-peptidase-like protein-6 is not only a regulatory subunit of neuronal Kv4.2 potassium channels, but also a biomarker for an immunotherapy-responsive multifocal neurologic disorder (insomnia and so on) of the central and autonomic nervous systems [8]. There are important role for Kv2.2-expressing neurons in the regulation of the sleep-wake cycle [9]. The polyunsaturated fatty acids were associated with sleep efficiency and rapid eye movement sleep (REMS) [10]. L-ornithine has the potential to improve sleep quality for fatigue [11]. The advantage of orexin antagonists is the promotion and maintenance of physiological sleep which should avoid hangover phenomena of approved treatments [12]. The robust REMS-inducing effect of melanin is likely related to the deactivation of monoaminergic, orexinergic, glutamatergic, cholinergic and GABAergic neurons [13]. Diet and nutrient intake contribute to insomnia [14]. The notion that food directly affects sleep is difficult to address, as which diet can boost sleep remains unclear. We aimed to seek constituents of functional foods promoting sleep by complex interaction between diet and sleep, which may help generate molecular mechanisms for future studies in human beings.

MAJOR INSOMNIA RISK FACTORS

Heredity is a Major Factor that Cause Insomnia

Insomnia may be influenced by an epigenetic control process between sleep mechanisms and gene-environment interactions having an impact on brain plasticity [15].

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Insomnia is 43% to 55% heritable in humans [16]. High heritability of insomnia persists except for psychiatric disorders [17]. The dysregulation of *ROR1*, *PLCB1*, or *PLCB4* by *PAX6* and *CTCF* is one neural mechanism associated with pancreatic dysfunction in insomnia [18]. Sleep is controlled by *PGC-1α* genes, but *Apoε4* plays an important role in insomnia [19]. Melatonin receptor genes may be associated with insomnia in schizophrenia patients [20]. The intronic SNPs in the *PRIMA1* and near *GBP4* gene have been identified as influencing caffeine-induced insomnia [21]. *PER3* genotype contributed variance in insomnia severity for alcohol-dependent patients [22]. Opioid receptor *mu1* gene is involved in the physiology of heroin and alcohol addiction [23]. Fatal familial insomnia is a hereditary autosomal-dominant mutation of the prion protein gene by motor disturbances in which the thalamus is a crucial switch [24]. Chronic sleep deprivation causes the expression of more than 700 genes, which are related to inflammation and immune and stress response [25]. Sleep duration is genetically regulated by *rs2031573* and *rs1037079* that may contribute to the regulation of sleep duration *via* gene expression [26]. The molecular mechanisms for the circadian clock regulate sleep such that a novel signaling molecule is mediated *via* distinct neuronal pathways [27]. Humans homozygous for the *PER3*(5/5) allele are more sensitive to non-image-forming light effects, as indexed by specific changes in sleep EEG activity [28].

The Loss of Components from whole Grain to Polished Grain Foods are Key Factors that Cause Insomnia

GABA is an inhibitory neurotransmitter and promotes parasympathetic activity for improved sleep, which is a functional food ingredient of safety use [29]. Some nutrients (calcium, potassium and magnesium) are associated with improved sleep [30]. Cav2.3 E-/R-type voltage-gated calcium channels modulate sleep [31]. The ion channel subunits contribute to the somatodendritic delayed rectifier, A-type and calcium-activated SK potassium currents, IH, L- and T-type calcium currents in the control of sleep, learning and nervous system disorders [32]. Ketamine and magnesium association reduces the post-operative morphine consumption after scoliosis surgery, which seems to provide better sleep quality and improves patient satisfaction [33]. Rice and wheat are staple foods of more than 70% of the worlds' populations. The loss of GABA from brown rice to white rice in the world in 2013 was estimated to be 70,323 tons; The loss of potassium and magnesium as well as calcium from brown rice to white rice in the world in 2013 were 929,765 tons and 485,875 tons as well as 31,599 tons, respectively (unpublished data). The loss of potassium and magnesium as well as calcium from whole grains to white flour of wheat in the world in 2013 were 4,782,778 tons and 1,414626 tons as well as 162,944 tons, respectively (unpublished data). The loss of GABA and other nutrition-related sleep from whole grains to polished grain foods are key factors that cause insomnia.

Some Foods and Beverages are Key Factors that Cause Insomnia

Foods rich in sugar, caffeine, green tea, etc can contribute to insomnia. The poor sleep quality and short sleep duration are more closely related with prediabetes than long sleep duration [34]. Sleep duration is inversely associated with higher intake of sugar [35]. Protein and carbohydrate intake in diet is associated with insomnia [36]. Short sleep duration is associated with increased energy consumption [37]. The sleep duration is inversely associated with serum leptin and dietary energy intake, while, short sleep contributes to hyperphagia, insulin resistance and obesity [38]. Excessive caffeine consumption (i.e >500 mg per day) can cause negative health consequences such as insomnia, psychomotor agitation, headache and gastrointestinal complaints [39]. Habitual coffee consumption is associated with reduced mortality and risks for arrhythmias, but caffeine at high doses can increase insomnia, anxiety and calcium loss [40]. In addition, smoking is associated with increased insomnia [41].

Disease: A Major Factor Causing Insomnia

Insomnia not only remains a significant risk factor for depression, anxiety, fibromyalgia, rheumatoid arthritis, whiplash, arthrosis, osteoporosis, headache, asthma and myocardial infarction, but is also significantly associated with the incidence of angina, hypertension, obesity and stroke [42]. Some sleep disorders and related problems are reported as risks leading to dementia [43]. It was observed that moderate traumatic brain injury patient (70.73%) had significantly higher occurrence of insomnia than the mild cases (19.67%) [44]. The similarity and difference in global gene expressions among patients with sporadic Creutzfeldt-Jakob disease, fatal familial insomnia and Alzheimer's disease, may help understand the common mechanism of neurodegenerative diseases [45]. Melatonin has a protective effect against lung inflammation associated with insomnia [46]. Sleep disorders are also known to be associated with diabetes and obesity [47]. Sleep apnea and obesity are strongly related, which highlights that sleep apnea is independently associated with early atherosclerotic plaque burden for coronary artery calcium in nonobese patients [48]. Epidemiological studies have supported an association between decreased self-reported sleep duration and an increased incidence of type 2 diabetes, obesity, and cardio-vascular disease, which may help in the development of new preventive and therapeutic approaches against obesity and type 2 diabetes based on increasing the quality and/or quantity of sleep [49].

Psychology: The Most Important Risk Factor Causing Insomnia

Sleep is a very complex physiological process. Insomnia has been suggested to cause depression and other mental disorders [50] such as, a correlation between global cognitive function and sleep disturbances in Parkinson's disease patients has been observed [51]. Chronic insomnia is best managed using cognitive behavior therapy [52]. Insomnia symptoms are positively associated with suicidal ideation, which is accounted for by depressive symptoms as evident in Japanese white-collar workers [53]. Melanin concentrating hormone stimulation can counteract the arousal neurons in the treatment of insomnia [54]. The alterations in the diurnal activity increase the risk of mood disorders among insomniacs [55]. Short or long sleep duration is an important sleep-related factor associated with memory impairment [56].

NATURAL FUNCTIONAL FOODS PROMOTING SLEEP IN HUMAN BEINGS

Sleep has an influence on eating behaviors, with insufficient sleep causing changes in the brain activity that may increase caloric consumption [57]. The consumption of high-protein and carbohydrate intake may have a significant influence on sleep [58]. Diet is a modifiable factor for improving sleep, but the associations of macronutrient intakes with insomnia are inconsistent.

Major Strategies of Functional Foods with High Components Promoting Sleep

Functional Components Promote Sleep

Zolpidem is a widely used hypnotic drug and a positive allosteric modulator of GABA with α 1-subunit containing GABAA receptors (α1-GABAARs) [59], however, α1-GABAARs play a significant role in hypnosis, electro-encephalogram sleep and anticonvulsant effects [60], but currently approved treatments for insomnia primarily target GABA-A receptor signaling [61]. A deregulation of Ca^{2+} signaling based on the neurons and inflammatory responses in the microglia and astrocytes may influence cognition by interfering with the rhythm rheostat that controls the sleep/wake cycle [62]. Sleep disorders are cardinal manifestations of voltage-gated potassium channel complex autoimmunity in association with a spectrum of neurologic presentations [63]. The hypoglossal motor activity in REMS is a muscarinic receptor mechanism linked to G-protein-coupled rectifying potassium channels [64]. A moderate magnesium deficiency may enhance inflammatory, including disrupted sleep/sleep deprivation [65]. Zinc and copper mediate sleep in the central nervous system, however, Zn/Cu ratio in the serum and hair is associated with sleep duration [66]. Reduced selenium or calcium intake has also been highlighted to be associated with insomnia [30]. Tryptophan and serotonin as well as melatonin in foods may be the most useful in promoting sleep [67]. The sleep-wake cycle is not only associated with many neurotransmitters, which include GABA, serotonin, orexin, melanin, cholinergic, galanin, noradrenaline, and histamine, but is also related with excessive nutrition, which includes carbohydrate, tryptophan, valerian, melatonin and so on [68].

Maca Promotes Sleep

Yunnan is the biggest production base for maca in China [69]. Maca grown in altitudes 2800-4500 m in Yunnan province of China not only enhances fertility chances, but is also reduces the glucose levels and prostate size, lowers blood pressure, improves memory, anxiety and depression, provides relief in osteoporosis as well as show, antioxidant, antiaging, antifatigue, antiviral activity, etc [70-72]. Moreover, a number of functional components are associated with improved sleep, e.g. hexadecanoic acid (22.73%) in fatty acids, calcium (974.63 mg/100g) and potassium (903.65 mg/100g) [73,74]. The main components of 90 compounds of essential oils for maca are [(1,1-dimethylethoxy) methyl]-benzene, N-(phenylmethyl)- acetamide, phthalic acid hexyl octyl ester, 1-isocyano-2-methyl-benzene,benzyl nitrile and methoxy-acetaldehyde [75].

Panax Promotes Sleep

Panax notoginseng flower and leaf showed improvement in sleep function [76]. Effective parts in *Oplopanax elatus* have a significant role of improving sleep. The best effective dose for 64 g /kg is during 7 days, which is related to central neurotransmitter and nitric oxide adjustment mechanism [77]. *Panax ginseng* demonstrated anxiolytic effects in a human trial [78]. The red ginseng extract intake can improve the quality of sleep [79]. There is significant alleviation in insomnia, flushing, perspiration and appetite by Korean red ginseng consumption [80]. The improvement of fermented ginseng acts *via* GABAergic modification [81].

Lingzhi Promotes Sleep

Ganoderma lucidum has been used as a tranquilizing agent for the treatment of insomnia in China, which is associated with the modulation of cytokines such as TNF-α [82]; Its basidiocarp, mycelia and spores contain 400 different bioactive compounds, some of the ingredients can promoting sleep [83]. Cracked Lingzhi Spores Powder could improve the sleep function of mice [84].

Other Foods Promote Sleep

Instant asparagus powder could improve the sleeping quality of mice [85]. Enzyme-treated asparagus extract intake is effective to modulate the sleep state among those with low sleep efficiency or excess sleep time [86]. The *Gastrodia elata* or its ultrafine powder at 40 mg/kg·BW dosage could improve the sleeping quality of mice [87, 88].

Sleep Duration Associated with Barley Grass

Barley grass powder promotes sleep due to the presence of GABA, and calcium, magnesium as well as B vitamins. Barley grass powder for Yungong brand was made from the leaves and stem of seedling barley, which is rich in a lot of high functional components improving sleep, because its GABA concentrations are 62.5 times than that of polished rice; calcium (845 mg/100g) and potassium (3110 mg/100g) concentrations in barley grass powder are 99.6 times and 31 times higher than those of polished rice [89]. The downregulated GABAB-R2 receptors in GABA-signaling are essential for sleep maintenance *via* l-LNv neurons in the circadian clock circuit [90]. A decline in GBAB-A receptor signaling triggers hyperactive sleep disorders, which reveals the GABAergic neurotransmission for pentameric ligand-gated ion channels [91]. The natural Mg^{2+}, N-methyl-D-aspartic acid antagonist and GABA agonist play a key role in sleep regulation [92]. The loss of GABA, potassium, magnesium and calcium from brown rice to white rice of China in 2013 was 20,403 tons, 269,763 tons, 140,972 tons, and 9,168 tons, respectively; but the loss of potassium and magnesium as well as calcium from whole grains to white flour of wheat of China in 2013 was 835,128 tons, 247,010 tons, and 28,452 tons, respectively (unpublished data). Rice and wheat are staple foods of more than 70% of the worlds' population. The dietary consumption of rice with high glycemic index is associated with good sleep [93]. Therefore, ideal foods to improve sleep for modern people are polished rice or wheat flour plus barley grass powder as well as its products.

The dietary flexibility of early *hominins* for grasses represents a significant distinction between great apes and common ancestors [94]. Adequate sleep is associated with low calorie foods in overweight adults [95]. Excess weight and obesity due to high fat or low fibre foods are factors that are strongly associated with the risk for Obstructive Sleep

Apnea [96]. Sleep deficiencies associated with metabolic dysregulation may contribute to obesity, diabetes and cardiometabolic disease [30], potentially by altering food intake, inflammation, impairing glucose tolerance and insulin sensitivity [97].

Major Methods of Vegetable-Fruits with High Components Promote Sleep

Food choices based on vegetable and fruit consumption are significantly associated with sleep duration (>8 h/night) [98]. A low intake of vegetables and fish and high intake of confectionary and noodles are independently associated with poor sleep quality [99]. Traditionally, lettuce has been recommended for its hypnotic property, with the main component found in n-butanol fraction of this plant [100]. Cherry ingestion may contribute to establish a high-quality sleep and be used as a potential nutraceutical tool to prevent sleep disorders with the advancing of age [101]. The consumption of a tart cherry juice concentrate provides an increase in melatonin that is beneficial in managing disturbed sleep [102]. The walnut may contribute to improved sleep based on the highest content in the antioxidants melatonin, serotonin and total polyphenols [103]. Kiwifruit consumption may improve sleep onset, duration and efficiency in adults with self-reported sleep disturbances [104].

Functional Beverages with high Components Promoting Sleep

Schisandra wine could improve the sleep of mice as a healthy food [105]. Moreover, milk with high melatonin and calcium consumed at night improves sleep quality in rats [106]. Tryptophan can increase the production of niacin, serotonin and melatonin. The alcoholic and malolactic fermentation during the making of 5 monovarietal wines plays a key role in the formation of melatonin and other 11 biogenic amines [107].

MOLECULAR MECHANISM OF FUNCTIONAL FOODS PROMOTING SLEEP

Mechanism of Tryptophan Promoting Sleep

Molecular mechanism of functional foods with high tryptophan content promotes sleep (see Fig. **1**), especially barley green of Puritan's Pride (1.20%). It has an impact on the availability of tryptophan as well as the synthesis of serotonin and melatonin, aiding in promoting sleep [57]. Tryptophan is not only a precursor of the neurotransmitter serotonin and the neurosecretory hormone melatonin for sleep/wake [108], but it is also metabolized in the brain along different pathways to serotonin, melatonin and niacin and is partly used as a source of protein synthesis [67]. The dietary tryptophan through the blood-brain barrier is favored by competing large neutral amino acids and carbohydrates; 5-hydroxytryptophan is converted to serotonin by aromatic L-amino acid decarboxylase and pyridoxine, however, serotonin is converted to melatonin by arylalkylamine-N-acetyltransferase and n-3 fatty acids [67]. Acetylcholine neurons modulate both arousal and REMS in combination with disturbed melatonin metabolism that might be involved in the sleep disorders in Cockayne syndrome [109].

Mechanism of GABA Promotes Sleep

Molecular mechanism of functional foods with high GABA content promotes sleep (see Fig. **1**), especially barley grass powder of Yungong (0.33%) and red ginseng as well as *Ganoderma lucidum*. GABA is the main inhibitory

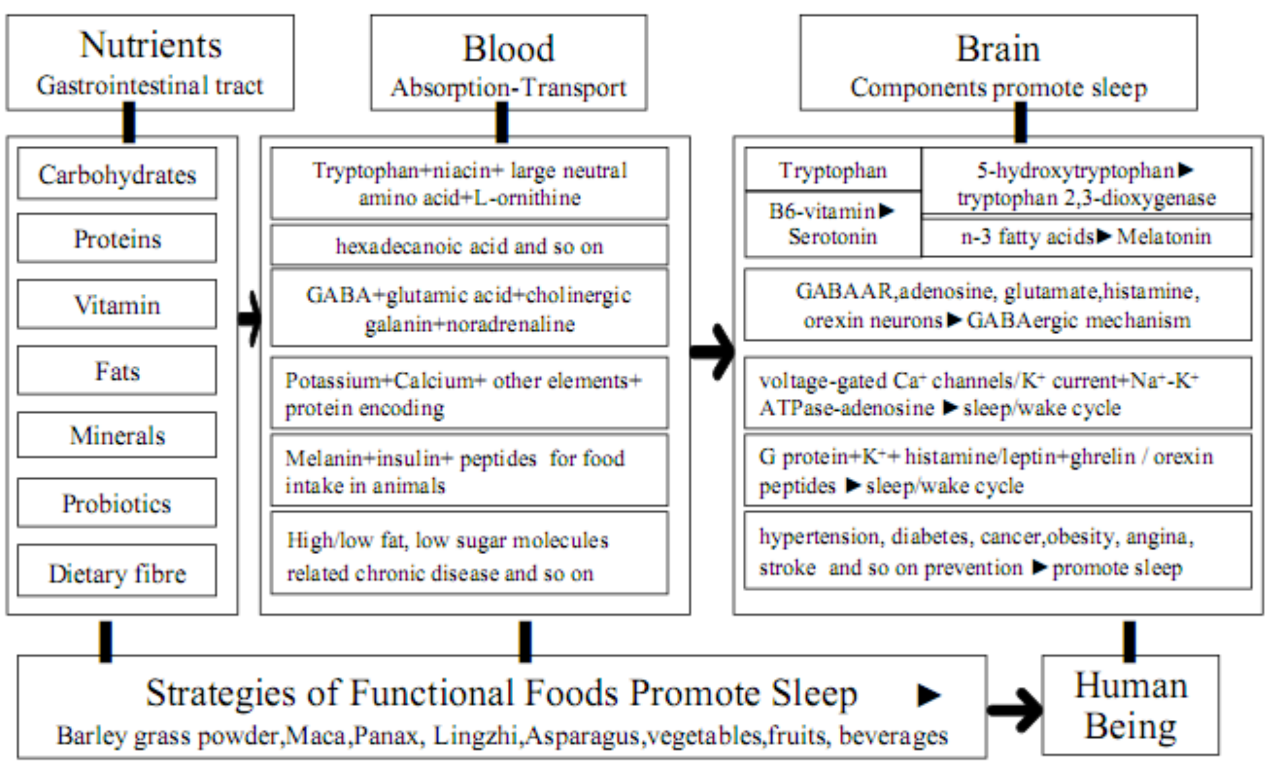

Fig. (1). Possible mechanisms of functional components in foods promote sleep.

neurotransmitter of the central nervous system and activation of GABA(A) receptors favors sleep [67]. GABAergic medullary parafacial zone neurons can potently trigger a slow wave sleep and modulate the cortical electro-encephalogram [110]. The receptor was crystallized bound to a previously unknown agonist, benzamidine, opening a new avenue for the rational design of GABAAR modulators [91]. The level of α/β-subunits of GABAAR was reduced, but glutamic acid decarboxylase were over-expressed in the hypothalamus. Red ginseng extract increased non-REMS *via* GABAAergic systems [111]. *Ganoderma lucidum* aqueous extract significantly decreased sleep latency, increased sleeping time, non-REM sleep time and light sleep time in pentobarbital-induced sleep *via* a GABAergic mechanism [112]. The potentiation effects of kiwifruit peel ethanol extracts on pentobarbital-induced sleep in mice may be modulated by a GABAergic mechanism [113]. The increased glutamate levels in the posterior hypothalamus activate histamine neurons and contribute to caffeine-induced waking and alertness, but GABA levels do not significantly change [114]. The robust REMS-inducing effect of melanin-concentrating hormone is likely related to the deactivation of monoaminergic, orexinergic, glutamatergic, cholinergic and GABAergic neurons involved in the generation of wakefulness and the inhibition of REM sleep [13]. The sleep-promoting action of adenosine can be reversed by orexin A applied to the lateral hypothalamus and exciting glutamatergic input to orexin neurons *via* the action of orexin receptor 1 [115]. A2AR-mediated activation of median preoptic nucleus and ventrolateral preoptic for two hypothalamic area GABAergic neurons contributes to adenosinergic regulation of sleep [116]. A2AR plays a predominant role in sleep induction, whereas A1R regulates the sleep-wake cycle in a site-dependent manner [117]. Ethanol promotes sleep by increasing adenosine in the orexinergic perifornical hypothalamus, resulting in A1 receptor-mediated inhibition of orexin neurons [118].

Mechanism of Ca-K Promote Sleep

Molecular mechanism of functional foods with high Ca and K content promotes sleep (see Fig. **1**), especially barley grass powder of Yungong and Maca. The key role is played by Ca^{2+} entry through thalamic T channels in the modulation of other voltage-dependent channels that are important for the generation of both slow waves and sleep spindles [119]. Voltage-gated Ca^{2+} channels are key elements in mediating thalamocortical rhythmicity. Low-voltage activated CaV2.3 R-type Ca^{2+} channels in the thalamocortical loop and extra-thalamocortical circuitries regulate rodent sleep architecture, which are related to the generation of non-rapid eye movement sleep [120]. The orexin activates mTORC1 *via* extracellular calcium influx and the lysosome pathway involves v-ATPase and Rag GTPases for chronic sleep disorder [121]. The upregulation of proteins encoding inward rectifier K^+ current, delayed rectifier K^+ current, acetylcholine activated K^+ current, transient outward K^+ current and ultra-rapid delayed rectifier potassium current as well as downregulation of protein encoding L-type Ca^{2+} current were found after chronic obstructive sleep apnea [122]. The Na^+-K^+ ATPase-dependent adenosine efflux is likely to provide the regulation of sleep by adenosine-mediated activity [123].

Mechanism of Hormones Promoting Sleep

Molecular mechanism of some hormones for food intake in animals promotes sleep (see Fig. **1**). Histamine inhibits melanin-concentrating hormone neurons for the regulation of REMS through histamine-3 receptors by activating G protein-dependent inwardly rectifying potassium channels and wake-active histaminergic neurons for the regulation of sleep and arousal [124]. The insulin may be responsible for paradoxical sleep deprivation-induced dysregulation in energy metabolism for food intake, however, reduced leptin levels are compensated by increased expression of leptin receptors in the hypothalamus, whereas no compensations occur in insulin receptors [125]. Sleep restriction is not only associated with a decrease in circulating levels of leptin and an increase in circulating levels of ghrelin, but also a stimulation of brain regions sensitive to food stimuli, which is likely to contribute to the current epidemics of type 2 diabetes and obesity [126]. Some neurons in the thalamus contain acetylcholine, dopamine, cholecystokinin and histamine, however, the forebrain / hypothalamic projections to posterior and lateral posterior may play a role in the migraine attacks triggered by disrupted sleep, skipping meals and emotional reactions [127]. The orexin peptides and their receptors are involved in the regulation of sleep/wakefulness state, energy homeostasis and reward seeking [128].

Mechanism of Disease Prevention Promoting Sleep

Molecular mechanism of functional foods for chronic diseases prevention promotes sleep (see Fig. **1**), such as hypertension [129], diabetes [130] and cancer [131]. Gongmi No.3 with the highest retrograded resistant starch in the world is the most ideal rice product to prevent chronic diseases in the World, especially diabetes [132]. Sleep disorder has detrimental effects on metabolic health, which may help in the development of new preventive and therapeutic approaches against obesity and type 2 diabetes based on increasing the quality and/or quantity of sleep [133]. The sleep disorders may be important, modifiable Coronary Artery Disease risk factors in the Indian population [134]. The short self-reported sleep duration is related significantly to an increased risk of reduced glomerular filtration rate in a hypertensive population [135]. Insomnia associated with physiological hyperarousal is associated with a significant risk of hypertension [136].

CONCLUSION AND FUTURE PROSPECTS

This review reveals that sleep disorders are related to functional components of some diets. Experimental studies have demonstrated that major insomnia risk factors are as follows: heredity, chronic disease, psychology, the loss of components from whole grain to polished grain foods, some foods and beverages. Tryptophan is an ingredient producing serotonin for inducing calmness and drowsiness; GABAergic parafacial zone is a sleep promoting center; Voltage-gated Ca^{2+} channels are key elements in mediating thalamocortical rhythmicity; Orexin peptides and their receptors are involved in the regulation of sleep/wake; and Functional foods for chronic diseases prevention promote sleep. There are higher functional components in functional foods that promote sleep, including tryptophan, GABA, calcium, potassium, melatonin, pyridoxine, L-ornithine and hexadecanoic acid;

but wake-promoting neurochemical factors including serotonin, noradrenalin, acetylcholine, histamine, orexin and so on. Although diet promoting sleep is limited for clinical evidence, they may be useful in a number of cases. According to the reviewed studies, eating functional foods may promote sleep, including barley grass powder, whole grains, maca, panax, Lingzhi, asparagus powder, lettuce, cherry, kiwifruits, walnut, schisandra wine, and milk; Barley grass powder for Yungong brand rich in a lot of high functional components improves sleep, because its GABA concentrations are 62.5 times than that of polished rice; calcium and potassium concentrations in barley grass powder are 99.6 times and 31 times than that of polished rice, respectively. Barley grass powder with higher GABA and calcium, potassium as well as tryptophan is the most ideal functional foods to improve sleep. These results suggest that the sleep duration for modern humans is associated with food structure of ancient humans. Overall, there are higher functional components in functional foods most helpful in promoting sleep. These results warrant that future research may highlight the importance of diet promoting sleep quality.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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